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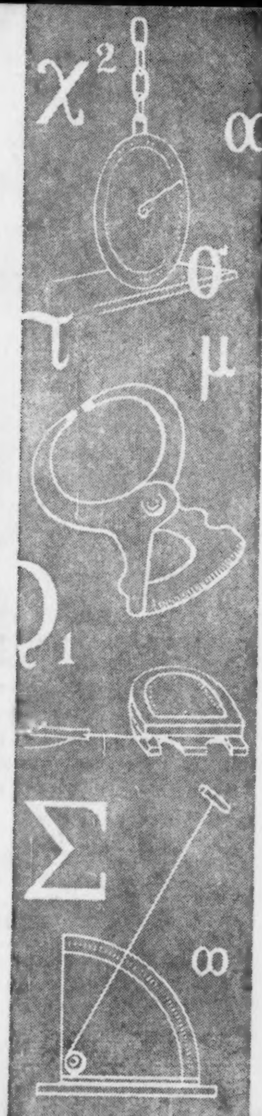

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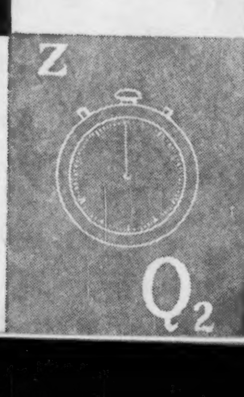

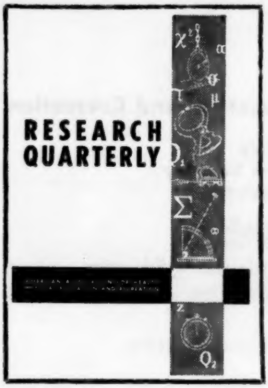

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Factorial Analysis of Physique and Performance in Prepubescent Boys[1]

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Abstract

The principal axes of an intercorrelation matrix ($n = 37$) of physique and performance data from 95 boys 7-11 years of age were located and rotated to an oblique simple structure in order to determine the nature of the factors involved in the physique of young boys and the relationships between these factors and performance. With the influence of body size virtually nullified by the rotation procedures, three type factors of physique were observed: one related to growth in transverse directions and adipose tissue, and two related to growth in vertical dimensions. Three factors related to motor performance were isolated: power, endurance, and dynamic shoulder strength. The morphological and performance measurements were found to be essentially unrelated.

ACCESS TO OBJECTIVE CRITERIA for the assessment of body build in children is a matter of practical importance for pediatricians, child development workers, psychologists, physicians, and physical educators. The voluminous literature bearing on problems of physical growth and development in children attests both to the intense interest in the area and to the relative ease with which body measurements may be taken, but as Keys and Brožek (25) have observed, "when one comes to the rationale of the measurements, especially as they are used for the characterization of body build, the outcome is much less satisfactory."

In physical education, it is widely held that in assessing performance, some adjustment or classification should be made for body or constitutional type, but there is less agreement as to how individuals may be classified, what adjustments should be made, how constant such ratings are throughout the school years, and so on. The conduct of crucial investigations along these lines will await, it seems, the development of objective criteria for constitutional type, enabling the use of matched groups with appropriate biological bases. The purpose of the present study was to determine, by means of the principal axes method of factor analysis and rotation to oblique simple structure, the nature of the factors involved in the physique of prepubescent boys, and to examine the relationships between these build factors and certain measures of motor performance.

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[1] This study was carried out in partial fulfillment of the Ph.D. requirements as framed by the Graduate College of the University of Illinois. R. B. Cattell (Personality Assessment and Group Behavior Laboratory) and Kern Dickman (Digital Computer Laboratory) each contributed as the occasion demanded. Their assistance is gratefully acknowledged.

Review of Previous Studies

The basic premises underlying the somatotyping technique of classifying body build, wherein inspection of the person is the coup de force, have been recorded by Kretschmer (26) and more recently by Sheldon (39). The work of these two pioneers in the study of human physique will not be reviewed here. The reader may refer either to the original sources or to the many reviews that have appeared in the literature (6, 25, 44).

The second major approach to the problem of classification has been the factorial analysis of morphological characteristics leading to hypothetical dimensions of body build. In general, little attempt has been made (in some 30 published papers) to examine the comparability of the findings, although Hammond (19) compared his factors derived from English children's data with those for American children measured by the United States Bureau of Agriculture for clothing purposes. He found considerable agreement between the factor loadings of 11 measurements common to both studies, with $r = 0.95$ in respect of loadings on the general factor, and $r = 0.90$ on the first type factor. Analyses have been made invariably on data collected for other purposes, and this fact, together with the limitation imposed by the factorial method that three measurements will not define more than one common factor, precludes any broad generalizations on the reality of the factors presented. Nevertheless, the findings are suggestive and may be summarized as follows: (a) the frequent appearance of a general factor accounting for approximately half of the total variance suggests that in human growth, as in other forms of animal growth, isometric development is dominant over allometric development (7, 19, 29); (b) where measures of skinfold fat have been included (28, 29, 40) a fat factor has emerged and has contributed highly to the total variance; (c) a differentiation has frequently appeared between cross-sectional and linear measurements and, in the case of the latter, between measurements of the limbs and trunk (7, 19).

Numerous studies have been reported showing the relationships in adults between body build and vocational tasks (16, 23), various sports skills (1, 11), and even exploring (34). The area is, however, virtually void of studies devoted to the prepubescent period.

The problems associated with relating growth to strength have been investigated in Danish children 6-17 years of age by Asmussen and Heebøll-Neilsen (2), who reported that with increasing height, dynamic strength increased more than would be expected from anatomical growth. It was assumed that a maturation of the neuromuscular system, which allows better muscular coordination, was responsible for this increase in muscular strength. Jones (22) considered both static and dynamic strength and their relationships to the growth of boys 11-17 years of age. He found that in boys 17.5 years of age, total strength correlated 0.52 with weight, 0.33 with height, 0.34 with mesomorphy, zero with endomorphy, and negatively with ectomorphy. The multiple correlation of these five factors was 0.87, leading Jones to conclude that constitutional factors (as contrasted with experiential or training factors) are of primary importance in determining individual differences in static strength, though not, apparently, in dynamic strength.

Several power tests (60-yd. dash, standing broad jump, and jump and reach) were related to anthropometric measurements and indexes by Espenschade (15) in boys 12-17 years of age. Correlations of broad jump and jump and reach showed a steady increase with age. Height correlated approximately 0.40 with the dash and broad jump at 13 years, slightly less at 15 years, and not at all at 17 years. It was suggested that the relationship between height and performance in these events is due to a common growth factor which is no longer operative after maturity is reached. In jump and reach, the order of relationship was reversed, this ability being more closely related to height at older than at younger age levels. An increasing relationship between the ratio stem length/height and the power tests was shown with increasing age, suggesting the possibility that body build may become a factor of increasing importance as growth in height and weight ceases. The ratio bi-iliac breadth/height correlated negatively with all the motor tests at 13 years and positively at 17 years, which may indicate that boys of a slenderer build excel in motor performance at 13 years, whereas those of stockier

build are superior at 17. In their investigation of vertical jumping, running, and acceleration in the Danish sample, Asmussen and Heebøll-Nielsen found that older boys performed better than younger ones in the same height classes. The influence of age was slight in tests of vital capacity and maximum breathing capacity, more pronounced in tests of muscular strength, and most so in those in which neuromuscular coordination in voluntary efforts can be expected to develop late, e. g., in flexion of the elbow as compared with extension of the legs, in acceleration as opposed to simple running. They attributed this to a gradual qualitative development of the neuromuscular system with age.

Breitinger (5) studied the effect of body form upon the physical achievement of 3000 Munich high school boys 10-20 years of age. Eleven body measurements (height, weight, girths, and breadths) and five performance tests, including a 60-meter run, standing broad jump, and high jump, were administered. He concluded that body growth (presumably in gross size) and athletic achievement run parallel and that there is no significant correlation between performance and physical proportion at any one age.

With respect to endurance, the most pertinent studies in an area remarkable for its lacunae are those in which the rate of oxygen intake during maximal work has been related to age. Astrand (3), Robinson (35), and Morse and others (31), have shown that when the rate of oxygen intake is expressed in terms of kg. of body weight, it is quite constant and bears no relationship to age.

Methods

SUBJECTS

Ninety-five boys 7-11 years of age who had been enrolled in the University of Illinois Summer Sports Fitness School for the summers of 1954 and 1955 comprised the sample. Since participation in the school is contingent upon the payment of fees, and in view of its location in a university environment, the sample was fairly homogeneous with respect to social and economic status. The frequency distributions of the variables were tabulated and inspected to determine extreme variations from the normal population. In general, the distributions were sufficiently normal to warrant inclusion, with chins and dips showing some positive skewness. Each subject was matched subjectively on sexual development according to the schema outlined by Schonfeld and Beebe (36). This resulted in the loss of 12 cases from the original sample; the analysis included data only from boys in the prepubescent stage of development.

SELECTION OF TESTS

The variables used were derived from three sources—anthropometric measurements and indexes obtained directly from nude subjects, anthropometric indexes derived from somatotype photographs, and performance measurements obtained in the laboratory or field. In selecting anthropometric measurements and indexes, consideration was accorded the meaningfulness of the measurements as determined from previous studies, the inclusion of both vertical and horizontal measurements, and an approximately equal representation of the upper and lower body. Specifically, the variables were as follows.

Direct anthropometric measurements and indexes. These were 16 in number: height; height/$\sqrt[3]{\text{weight}}$; height $\times$ 100/6 $\times$ transverse chest; arm span/height; biceps, calf, and thigh girth; thigh girth/knee width; shoulder

width; hip width; shoulder width/hip width; knee width; chest depth; chest circumference; subcutaneous fat (sum of six skinfolds); and weight. Skeletal measurements were taken according to the specifications of McCloy (30) and girth and skinfold fat measurements after the manner of Cureton (14). Test-retest reliability coefficients ranged from 0.99 for height to 0.88 for chest depth.

Indirect (photogrammetric) anthropometric indexes. Somatotype photographs were taken in three planes, and 10 length measurements and indexes were derived from them according to the method described by Cureton (12). These variables were: leg length, foreleg length, thigh length, leg length/trunk length, foreleg length/thigh length, trunk length, bust height, bust height/picture height, arm length, upper arm length/forearm length. Reliability coefficients were secured for these variables from measurements made on duplicate contact prints. The coefficients ranged from 0.99 for leg length to 0.89 for upper arm length.

Performance measurements. The following 10 performance measurements were included in the analysis: total strength (sum of left and right grip, back and leg strength), chins, dips, endurance hops, standing broad jump, 440-yd. run time, running broad jump, high jump, "drop-off" (440-yd. run time minus 7.33 × 60-yd. run time), and agility run. Three variables (vertical jump, 60 yd. run time, and total strength/weight) had shown a curvilinear relationship to age, and were consequently omitted from the analysis. The test-retest reliability coefficients were computed for six of the performance variables. They were generally lower than the anthropometric measurements (total strength, 0.90; chins, 0.86; dips, 0.77; agility run, 0.58; standing broad jump, 0.76; endurance hops, 0.61). Age in years and months completed the battery of 37 variables.

STATISTICAL PROCEDURES

The 667 intercorrelations of the 37 test items were computed on the University of Illinois Electronic Computer (Illiac), using the product-moment formula.

The principal axes method of factor analysis, originally conceived, although not applied, by Karl Pearson (33) in connection with the practical problem of identifying criminals by a set of "ideal index characters," was the first explicit procedure for carrying out a factorial analysis. By calculating the principal axes of the correlation ellipsoid, Pearson was able not only to express n correlated variables in terms of r uncorrelated components, but to express them in such a manner that the first of the hypothetical index characters accounted for as much of the individual variability as possible, the second for as much of the residual variance as possible, and so on. It is this unique property of the principal axes solution which renders it an ideal method of multiple classification. The mathematical bases for the procedures have been set out by Pearson (33) and Thurstone (43), while Hotelling (20) and Kelley (24) have simplified the computational procedures involved in finding the principal axes. In the present analysis, communalities (the highest corre-

lation coefficient in each column) were used in the diagnoals rather than unities.

Thurstone's technique (43) of rotating factors was designed to eliminate the meaningless interpretations of factorial analyses that were becoming prevalent in the literature. His objectives were fourfold: (1) parsimony in factorial description, (2) uniqueness, (3) invariance of factor loadings, and (4) meaningfulness. The major argument for its adoption in the present study lies in the meaningfulness of the factors, a judgment based more on the cumulative experience of previous workers and the results of their analyses than upon the proven scientific validity of a simple structure solution.

Rotational procedures were initiated with the application of Quartimax to the principal axes factor loadings derived from the matrix of intercorrelations. Quartimax is an attempt to arrive analytically at an orthogonal simple structure solution. Neuhaus and Wrigley (32), who developed the technique, have discussed the rationale of the method and its comparability to other solutions. Since the Quartimax rotation approaches, but does not consummate, a simple structure solution, 12 oblique rotations were carried out by hand.

The fact that general body size has appeared in several previous analyses has been noted above. This raises the inevitable question of the relative importance of the tendency toward distinct physical types as compared with the tendency for all humans to preserve rather similar body proportions. The appearance of a general factor merely indicates that even those individuals with extreme physiques resemble man more closely than any other animal form. The search for an oblique simple structure is an attempt to arrive at correlated factors which may serve to distinguish individuals, not in terms of discrete classes, nor on the basis of an anatomically complex general factor, but according to a relatively small number of factors, or coordinates, in terms of which each individual physique could ultimately be described.

Results

INTERCORRELATION MATRIX AND ORTHOGONAL FACTOR MATRIX

The intercorrelations of the 37 variables are presented in Table 1. The configurational changes normally associated with growth during the prepubescent period are evident in the correlations of the anthropometric data, with linear growth increasing more rapidly than transverse growth, and the lower limbs growing more rapidly than stem length. The high correlation (+ .0877) of thigh girth with the sum of six skinfolds suggests that, at this age level, thigh girth may be an adequate, simple method of evaluating the caloric aspects of nutritional status.

The correlations of the performance tests with the anthropometric measurements and indexes are, with the exception of total static strength, low. A clear differentiation is shown between the static and dynamic strength tests. The former (total strength) correlated + 0.718 with age, whereas chins and dips both show low, negative correlations (— 0.199 and — 0.132, respectively). In contrast, the relationships between static strength and the jumps (standing and running broad jumps and high jump), all approxi-

TABLE 1.—CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Age in months	-																
2. Height	.812	-															
3. Weight	.583	.769	-														
4. Height/$\sqrt[3]{\text{Weight}}$	.100	.022	-.594	-													
5. Biceps Girth	.424	.556	.888	-.668	-												
6. Calf Girth	.562	.710	.945	-.560	.873	-											
7. Thigh Girth	.471	.638	.950	-.662	.911	.912	-										
8. Ht. x 100/6xTr. Ch.	.174	.195	-.078	.344	-.163	-.103	-.128	-									
9. Shoulder Width	.642	.821	.770	-.211	.648	.743	.672	-.065	-								
10. Hip Width	.642	.771	.891	-.432	.780	.845	.818	-.134	.761	-							
11. Sh. Wdth/Hip Wdth	-.292	-.301	-.515	.392	-.484	-.490	-.502	.128	-.114	-.717	-						
12. Arm Span/Ht	.096	.045	.170	-.226	.197	.177	.143	-.258	.172	.274	-231	-					
13. Chest Depth	.495	.628	.841	-.486	.802	.803	.818	-.085	.641	.740	-.429	.078	-				
14. Chest Circ.	.510	.667	.911	-.604	.861	.849	.860	-.229	.734	.817	-.447	.175	.839	-			
15. Total Fat	.248	.417	.809	-.686	.834	.753	.877	-.269	.506	.682	-.476	.100	.738	.787	-		
16. Knee Width	.654	.828	.869	-.333	.718	.849	.784	.064	.747	.830	-.461	.178	.736	.779	.557	-	
17. Leg Length	.806	.945	.731	.043	.527	.690	.622	.175	.764	.734	-.300	.125	.570	.588	.394	.806	-
18. Trunk Length	.637	.846	.737	-.112	.581	.692	.647	.124	.743	.687	-.238	.019	.583	.665	.460	.786	.785
19. Leg L/Trunk Lgth	.493	.447	.247	.194	.122	.235	.187	.105	.292	.319	-.189	.182	.179	.116	.061	.296	.608
20. Foreleg Length	.775	.917	.684	.090	.481	.656	.574	.174	.717	.698	-.296	.142	.527	.553	.342	.790	.977
21. Thigh Length	.805	.931	.750	-.013	.564	.697	.648	.176	.771	.744	-.305	.102	.598	.607	.442	.793	.974
22. Foreleg L/Thigh L.	-.280	-.265	-.324	.215	-.312	-.251	-.325	-.021	-.313	-.298	.111	.026	-.306	-.270	-.335	-.201	-.247
23. Bust Height	.672	.859	.674	.002	.453	.622	.564	.280	.686	.636	-.227	.012	.500	.535	.292	.813	.815
24. Bust Ht/Picture Ht.	-.557	-.562	-.418	-.063	-.351	-.413	-.372	.040	-.459	-.441	.187	-.147	-.371	-.370	-.309	-.404	-.673
25. Upper Arm/Forearm L.	-.066	-.065	-.001	-.013	-.006	.039	.062	-.118	-.065	-.027	-.040	-.083	.030	-.096	.003	.000	-.024
26. Arm Length	.731	.905	.757	-.041	.572	.712	.648	.121	.766	.766	-.349	.275	.622	.645	.450	.818	.918
27. Thigh G/Knee Wdth	.195	.300	.714	-.689	.786	.683	.865	-.238	.410	.558	-.380	.077	.630	.652	.860	.371	.297
28. Total Strength	.718	.771	.689	-.169	.591	.641	.550	.120	.712	.682	-.284	.170	.619	.654	.356	.745	.705
29. Chins	-.199	-.345	-.463	.258	-.360	-.447	-.518	.203	-.364	-.451	.311	-.038	-.331	-.393	-.559	-.298	-.339
30. Dips	-.132	-.295	-.424	.263	-.344	-.370	-.468	.104	-.273	-.389	.295	-.143	-.362	-.374	-.557	-.263	-.344
31. Endurance Hops	.411	.224	-.026	.287	-.023	-.039	-.077	.051	.182	.080	.060	.062	.060	.071	-.155	.100	.167
32. St. Broad Jump	.558	.381	.070	.299	.002	.085	-.026	.356	.266	.139	.030	.023	.099	.059	-.270	.241	.331
33. 440 yd Run *	-.278	-.064	.304	-.495	.324	.276	.377	-.156	.108	.114	-.027	-.205	.217	.221	.464	.083	-.026
34. Running Brd Jump	.583	.404	.113	.315	.076	.134	.041	.305	.264	.217	-.082	-.054	.132	.034	-.170	.296	.422
35. High Jump	.672	.515	.192	.313	.068	.208	.072	.330	.317	.252	-.051	-.008	.192	.141	-.172	.363	.509
36. "Drop-off"*	.049	.218	.433	-.361	.434	.403	.451	.042	.338	.253	-.020	-.258	.349	.352	.417	.264	.210
37. Agility Run*	-.335	-.284	-.037	-.245	-.056	-.062	.014	-.178	-.189	-.126	.013	.164	-.127	-.145	.099	-.118	-.184

*Calculated with low scores at top of scale.

TABLE 1 (*Continued*)

18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
-																			
-.011	-																		
.787	.564	-																	
.749	.619	.909	-																
-.110	-.286	-.051	-.449	-															
.893	.173	.823	.771	-.086	-														
-.303	-.703	-.610	-.707	.403	-.212	-													
-.044	.008	-.002	-.042	.082	.043	.123	-												
.788	.479	.891	.906	-.769	.809	-.571	-.077	-											
.337	.063	.240	.345	-.324	.196	-.250	.100	.329	-										
.648	.317	.668	.716	-.278	.629	-.455	-.141	.723	.225	-									
-.310	-.153	-.295	-.362	.255	-.263	.242	.009	-.372	-.556	-.027	-								
-.143	-.372	-.279	-.403	.371	-.163	.479	.087	-.363	-.505	-.066	.626	-							
.071	.196	.156	.177	-.067	.117	-.126	-.272	.166	-.183	.281	.133	.135	-						
.220	.263	.313	.336	-.142	.310	-.236	-.079	.261	-.219	.509	.228	.261	.471	-					
.076	-.145	-.069	.014	-.193	.023	.072	.148	-.003	.474	-.143	-.321	-.246	-.547	-.565	-				
.224	.400	.413	.412	-.136	.350	-.287	.103	.280	-.158	.459	.209	.242	.439	.711	-.416	-			
.353	.364	.492	..493	-.112	.461	-.297	-.012	.391	-.168	.556	.134	.187	.372	.734	-.465	.655	-		
.297	-.046	.152	.249	-.281	.263	-.044	.081	.189	.447	.172	-.230	-.121	-.331	-.178	.847	-.070	-.097	-	
-.146	-.117	-.173	-.189	.057	-.093	.233	.096	-.142	.090	-.341	-.096	-.066	-.358	-.512	.415	-.401	-.468	.168	-

TABLE 2.—ORTHOGONAL (PRINCIPAL AXES) FACTOR MATRIX

Variable	I	II	III	IV	V	VI	VII	VIII
1. Age	.749	.486	.049	—.044	—.067	.014	—.063	.028
2. Height	.903	.319	—.053	.167	.078	—.103	—.074	—.017
3. Weight	.947	—.260	—.080	—.085	.005	.033	.023	—.032
4. R. P. Index	—.341	.724	.074	.346	.083	—.081	—.128	.076
5. Biceps Girth	.815	—.379	—.079	—.255	—.121	.024	.068	.043
6. Calf Girth	.903	—.243	—.088	—.113	.011	.085	.028	.075
7. Thigh Girth	.878	—.405	—.039	—.098	—.053	.055	—.078	.079
8. Ht. × 100/6 × Tr. Ch.	.010	.412	—.210	.243	—.130	.054	—.174	—.249
9. Shoulder Width	.837	.075	—.091	.044	—.016	—.255	.193	.141
10. Hip Width	.904	—.105	.064	—.183	.130	.120	—.033	—.117
11. Shoulder W./Hip W.	—.469	.205	—.195	.307	—.190	—.416	.238	.268
12. Arm Span/Height	.166	—.031	.274	—.268	.305	.066	.305	—.022
13. Chest Depth	.806	—.217	—.073	—.195	—.121	—.020	—.028	.045
14. Chest Circum.	.852	—.277	—.077	—.268	—.003	—.173	.063	.018
15. Subcutaneous Fat	.694	—.604	.093	—.109	—.065	—.075	—.113	.040
16. Knee Width	.900	.053	—.161	—.052	.156	.092	.067	—.084
17. Leg Length	.889	.322	.090	.280	.104	.046	.038	.049
18. Trunk Length	.805	.116	—.378	.128	.240	—.188	—.104	.010
19. Leg L./Trunk L.	.402	.351	.578	.222	—.145	.249	.153	.038
20. Foreleg Length	.841	.349	.032	.264	.245	.091	.030	.134
21. Thigh Length	.902	.278	.149	.268	—.047	.001	.033	—.056
22. Foreleg L./Thigh L.	—.352	.078	—.245	—.071	.459	.101	—.016	.197
23. Bust Height	.764	.267	—.390	.225	.255	.014	—.016	.197
24. Bust Ht./Picture Ht.	—.569	—.216	—.526	—.158	.183	.033	—.133	—.066
25. Upper/Forearm L.	—.030	—.100	—.116	.101	—.006	.387	—.086	.326
26. Arm Length	.883	.212	.071	.169	.210	—.054	.092	—.081
27. Thigh Gth./Knee Wdth.	.590	—.618	.097	—.093	—.199	—.001	—.183	.190
28. Total Strength	.770	.312	—.142	—.209	—.106	—.039	.198	—.113
29. Chins	—.445	.374	—.283	—.215	—.101	.155	.334	—.041
30. Dips	—.414	.345	—.554	—.202	—.001	.141	.162	.083
31. Endurance Hops	.113	.523	.104	—.329	—.073	—.274	—.001	.015
32. St. Broad Jump	.240	.734	—.108	—.251	—.277	.029	—.034	—.025
33. 440-Yd. Run [a]	.140	—.745	—.218	.460	—.233	.085	.113	—.050
34. Running Broad Jump	.294	.671	—.079	—.119	—.287	.271	—.045	.102
35. High Jump	.371	.708	—.114	—.102	—.179	.122	—.073	.018
36. Drop-off [a]	.349	—.437	—.390	.421	—.431	.061	.109	—.085
37. Agility Run [a]	—.166	—.460	.010	.250	.256	.172	.242	—.060
Sums of Squares	15.783	6.101	1.923	1.822	1.311	.855	.662	.466

[a]Calculated with low scores at top of scale. **Note: Factors I, II, and VIII have been reflected.**

TABLE 3.—OBLIQUE FACTOR PATTERN[a]

Variable	I	II	III	IV	V	VI	VII	VIII
1. Age	.079	.328	.119	.412	.127	—.065	.039	—.039
2. Height	.028	.062	.020	.625	.029	—.128	—.021	.017
3. Weight	.564	—.047	—.014	.214	—.163	.039	—.014	—.038
4. R. P. Index	—.777	.133	.070	.398	.247	—.202	.088	.055
5. Biceps Girth	.732	.042	—.012	—.051	—.186	.089	—.000	.040
6. Calf Girth	.582	.000	—.027	.172	—.138	.058	.098	.000
7. Thigh Girth	.640	—.087	—.008	.046	—.182	—.071	.086	—.002
8. Ht. × 100/6 × Tr. Ch.	—.355	.223	—.063	.321	—.155	—.143	—.148	—.188
9. Shoulder Width	.262	.041	.036	.415	—.065	.059	—.021	.323
10. Hip Width	.481	—.024	.025	.231	.054	.053	—.027	—.228
11. Shoulder W./Hip W.	—.428	.059	—.013	.085	—.154	—.007	—.008	.616
12. Arm Span/Height	.191	—.116	.138	.018	.315	.357	.010	—.082
13. Chest Depth	.586	.085	—.020	.039	—.124	—.021	—.009	.036
14. Chest Circum.	.629	—.011	—.084	.070	—.034	.048	—.119	.110
15. Subcutaneous Fat	.630	—.270	.044	—.135	—.147	—.157	—.017	.031
16. Knee Width	.341	.061	—.094	.447	—.049	.138	—.008	—.117
17. Leg Length	—.023	—.003	.204	.671	.007	—.032	.138	.003
18. Trunk Length	.096	—.030	—.355	.608	—.033	—.108	—.057	.091
19. Leg L./Trunk L.	—.121	.051	.706	.265	.073	.054	.224	—.106
20. Foreleg Length	—.054	—.018	.093	.710	.088	—.001	.240	.010
21. Thigh Length	.021	.016	.304	.591	—.069	—.067	.014	—.021
22. Foreleg L./Thigh L.	—.175	—.048	—.424	.066	.252	.122	.230	.001
23. Bust Height	—.030	.044	—.307	.721	—.078	—.044	.026	—.056
24. Bust Ht./Picture Ht.	—.014	.017	—.622	—.239	—.075	.046	—.076	—.083
25. Upperarm/Forearm L.	.104	.073	—.056	—.073	—.157	—.004	.490	—.008
26. Arm Length	.045	—.100	.118	.642	.069	.041	—.035	—.035
27. Thigh Gth./Knee Wdth.	.651	—.183	.080	—.273	—.209	—.237	.138	.092
28. Total Strength	.315	.376	.017	.332	—.031	.224	—.157	.006
29. Chins	—.100	.486	—.119	—.078	—.049	.447	—.023	.015
30. Dips	—.083	.509	—.432	—.023	—.069	.324	.075	.066
31. Endurance Hops	—.054	.382	.023	.038	.386	—.024	—.185	.107
32. St. Broad Jump	—.037	.711	.018	.150	.127	.032	—.063	—.044
33. 440-Yd. Run[b]	.242	—.403	.066	—.034	—.753	—.001	.035	.120
34. Running Broad Jump	—.005	.687	.105	.171	.014	.043	.195	—.090
35. High Jump	—.076	.605	.019	.303	.090	—.003	.058	—.082
36. Drop-off[b]	.250	—.059	.033	.107	—.840	.002	—.034	.151
37. Agility Run[b]	—.006	—.471	.033	.037	—.203	.244	.092	—.055

[a]Contains loadings on the reference vectors. Factors I, II, VII, and VIII have been reflected.
[b]Calculated with low scores at top of scale.

mately +.050, reflect the disproportionate development between the upper and lower body of prepubescent boys.

The unrotated factor loadings from the principal axes solution are presented in Table 2. Ten factors were extracted, but since the last two factors (Factors IX and X) had generally low loadings, they were omitted from subsequent rotational procedures. The principal axes method extracts factors in the order of their contribution to the total variance. This may be observed from the sums of squares of the factor loadings shown at the bottom of the table. The most significant characteristic of this matrix is the obvious presence of a large general factor, accounting for 43 percent of the total variance.

OBLIQUE FACTOR PATTERN

Factor loadings on the 37 variables after rotation to an oblique simple structure are presented in Table 3. The loadings presented in this matrix are actually loadings on the reference vectors, not the factors. Since the purpose of the present study was to determine the nature of the influences responsible for the relationships expressed in the intercorrelation matrix, and since the relative importance of all the variables on a given factor will not be changed by the transformation from loadings on the reference vectors to loadings on the factors, the results have been expressed in terms of the reference vector system. In using this system, however, the exact relative size of the factors (their average contribution to the variance of all the tests) is not discernible, nor is it possible to decide with assurance whether a particular variable is more highly associated with one factor than another when both influence it strongly, since the ratio by which r's are multiplied to transform them to loadings will differ with different factors, according to the cosine of the angle between RV (reference vector) and F (factor) (9). The reader is reminded, then, that what we hereafter call factors are actually reference vectors. The matrix of correlations among the rotated reference vectors (obtained by premultiplying the transformation matrix by its transpose) is shown in Table 4.

Factor I—Ponderosity. This factor was characterized by high positive loadings on girth measurements, subcutaneous fat, weight, chest depth and circumference, and the ratio thigh girth/knee width. High negative loadings

TABLE 4.—INTERCORRELATIONS OF REFERENCE VECTORS[a]

I	II	III	IV	V	VI	VII	VIII
1.000							
.295	1.000						
—.083	—.091	1.000					
—.592	—.259	—.074	1.000				
—.153	—.116	—.112	—.021	1.000			
.260	.190	.100	.090	—.150	1.000		
.098	.005	.081	—.048	.008	.010	1.000	
.011	.009	.009	.007	—.086	.000	.196	1.000

[a]The signs in columns I, II, VII and VIII have been reflected in accordance with similar reflections carried out in Table III (Oblique Factor Matrix).

occurred for the reciprocal of the ponderal index and shoulder width/hip width. The pattern of loadings emphasizes a bulky physique with substantial adipose covering and resembles somewhat the pyknic type of Kretschmer and Sheldon's endomorphy component. If one is addicted to the Sheldon typology, the correlation of this factor with Factor IV ($r = -0.59$) is interesting, as it indicates that bulkiness and thinness influence each other considerably.

This factor is essentially unrelated to the motor abilities included in the study, with the exception of total strength, which has a moderate positive loading. Sills (40), who included both leg lift and back lift in his analysis on college students, found that back lift had a moderately high positive correlation with the factor "endomorphy," so that one might infer that strength of the back is largely responsible for the positive correlation in this study.

The first factor corresponds well with McCloy's (29) "growth in fat" factor and Marshall's (28) "fat factor," both found in analyses of young boys' data. Hammond (18) concluded, however, that whereas weight was the best indicator of general size, subcutaneous tissue was the least indicative. It is this anatomical complexity of general factors that prompted the search for an oblique simple structure in the present data.

Factor II—Power. The high loadings on standing broad jump (+ 0.711), running broad jump (+ 0.687), high jump (+ 0.605), dips (+ 0.509, chins (+0.486), and agility run (—0.470) indicate that power is emphasized, with a premium on the ability to handle the body weight both in a single explosive effort and over a period of time. The moderate loadings on total strength, endurance hops, and 440-yd. run suggest that this factor possesses strong traces of general motor ability. Nevertheless, it differentiates primarily between those with high and those with low power, and from the low correlations with the other factors, it is seen to be relatively free from consitutional influences. The moderate loading on age (+0.328) is consistent with the developmental curves for these variables in prepubescent boys, while the low negative loading on subcutaneous fat (— 0.270) and the low positive loading on the thinness index of height $\times$ 100/6 $\times$ transverse chest (+0.223) connote a slight advantage for the lean, linear boy in these motor activities. This factor is, however, essentially unrelated to morphological characteristics.

Factor III—Leg-Trunk Development. This factor is obviously related to Kretschmer's "elongated eunochoid," but since ratings of sexual characteristics were not included in the analysis, it was deemed more appropriate to label it in terms of the skeletal pattern indicated by the loadings, i. e., long legs (especially thigh length) and short trunk. The characteristic body build implicit in this factor is a dysplastic one, which is virtually overlooked in Sheldon's typology. The negative loadings on the two dynamic strength tests involving the shoulder girdle (chins and dips) are meaningful, but the differentiation in the size of the loadings, indicating greater development of the extensor muscles of the arm than the flexors, is perplexing. The factor is a very clear theoretical exposition of a frequently observed manifestation of

prepubescent growth. It bears no relationship to the motor abilities included in the study, with the exception of the two dynamic strength tests referred to above.

Factor IV—Lankiness. The pattern of loadings on this factor bears some similarity to the characteristics in those Sheldon labeled ectomorphic. It is probable that some traces of the general factor found in the orthogonal factor matrix are present in this factor, as it has moderately high loadings on two breadth measures (shoulder and knee). McCloy (29) found a similar intrusion of breadth measures into a predominantly linear factor in children of this age, leading to the labeling of the factor as general growth. He suggested, however, that this type of growth would result in persons "very tall, long-limbed and excessively slender."

Although no measurements of head size were included in this study, some insight into neural development is provided by the comparative loadings on bust height (+0.721) and trunk length (+0.608). These loadings indicate that growth in head size is marked at this age level, suggesting that neural growth may be emphasized. McCloy (29), who included head measurements in an analysis of girls' data, found a neural growth factor, which "is seen in those individuals with large heads and eyes that are out of proportion to the size of the rest of the body."

The general size factor, which was seen to be marked in the orthogonal solution, has been virtually, though apparently not completely, nullified in the process of rotating to an oblique simple structure. The result was one factor (Factor I) which is primarily concerned with growth in cross section and another (Factor IV) which largely determines growth in vertical dimensions. It is not surprising then that both should have moderate loadings on total static strength or that the growth influence of Factor IV should favor performance in a motor skill like high jumping.

Factor V—Endurance. In view of the frequent references made by physical educators to the development of organic efficiency, the isolation of an endurance factor as one of the dimensions of performance in young boys is of considerable interest. The relationship of the factor to the morphological variables suggests that boys with high endurance tend to be linear and to have long forelegs (in relation to thigh) and arms. The relatively low loadings of these morphological variables, and the low correlations of this factor with Factors I and IV, which are primarily concerned with general or isometric growth, indicate that the development of endurance in children is influenced more by environmental than constitutional forces. The amount of vigorous activity engaged in by the boys in this sample and its effects on the cardiovascular system are suggested by these data as being the cardinal influence in the development of endurance.

Factor VI—Dynamic Shoulder Strength. The relatively low loadings, and especially the combination among the loadings of two types of strength (static and dynamic), made the naming of this factor something of an enigma. The pattern of loadings indicates that the morphological and performance variables are more closely related than in previous factors, and it

is possible that this factor is related to Kretschmer's athletic type or Sheldon's mesomorphy.

Strength has been related to mesomorphic characteristics by many workers (22, 40). Sills, using college students as subjects, found high loadings for dips and chins on his mesomorphy factor. The factor was not clearly isolated, a fact which Keys and Brožek attributed "undoubtedly" to "an absence of reasonably pure morphological measures of muscle "mass" (25). An equally likely reason for this lack of clarity would seem to be the inadequacy of the factor resolution resulting from the use of orthogonal rotational procedures.

The low loadings in this factor on measurements usually related to general size, and the low intercorrelations with Factors I and IV (+ 0.29 and + 0.09, respectively) are in agreement with the complexities, noted by Jones (22), involved in relating strength to body build in boys. He observed that strength was frequently expressed in short, stocky boys, in whom strength was handicapped not by lack of relative muscularity but by small skeletal size and consequent deficiency in total muscle mass. When Jones partialled out height and weight, the correlation between strength and mesomorphy was + 0.61, while the multiple correlation between strength and five other variables (endomorphy, mesomorphy, ectomorphy, height, and weight) was found to be + 0.87. From this, Jones concluded that little of the variance in strength may be attributed to "other factors, such as those associated with the exercise or functional training of specific muscle groups." This conclusion appears not entirely adequate, however, since training and nutritional variables influence both the criterion and the contributing causal variables, making so neat a separation of the effects of constitutional and environmental influences questionable. Cureton (11) has shown that muscular girth increments in response to training are greater in those of mesomorphic build than in ectomorphs, and it is probable that there are, indeed, constitutional limits, determined primarily by the number of muscle fibers, to the upper levels of achievement in activities requiring strength.

Factor VII—Segmental Limb Development (*tentative*). This factor was observed to contribute little to the total variance. It is obviously related to growth in specific segments of the limbs, especially the upper arm. The factor is essentially unrelated to any of the previous factors.

Factor VIII—Androgynous Growth (*tentative*). This factor was observed also to contribute little to the total variance. The association of the factor with androgynous growth is based on the work of Seltzer (37) and of Bayley and Bayer (4), who attached importance to the relative width of the shoulder and hip in the development of andric and gynic characteristics. If this factor is related to androgynous growth, then its low contribution to the total variance might be the result of the age group used in the sample. Further analyses of data derived from older and younger children would clarify the interpretation of this factor.

SECOND ORDER FACTORS

A further principal axes factor analysis was carried out on the matrix of intercorrelations between the first order factors. The first two factors were

rotated obliquely, resulting in the factor (reference vector) matrix shown in Table 5. The first factor (X), with high loadings on F_I (ponderosity) and F_{IV} (lankiness), is obviously one of general size and reflects the partialling out of age during rotation to simple structure.

TABLE 5.—OBLIQUE SECOND ORDER FACTOR MATRIX[a]

	X	Y
F_I	.780	—.030
F_{II}	.079	.275
F_{III}	.274	.241
F_{IV}	.763	.045
F_V	.129	.259
F_{VI}	—.493	—.020
F_{VII}	.034	—.422
F_{VIII}	—.124	.387

[a]Both second orders factors have been reflected. The factors intercorrelate +0.26.

The moderate negative loading on F_{VI} (dynamic shoulder strength) may be interpreted as indicating that in prepubescent boys, dynamic strength, at least as measured in this study, bears an inverse relationship to body mass. This agrees with the observation of Jones (22) that strong boys are often small and stocky, although it must be remembered that the two dynamic strength tests included in the analysis (chins and dips) would favor those of small build. The appearance of Factor_{VI} on this second-order size factor, together with the first-order factors of ponderosity and lankiness, raises the question of whether the second-order factor points to the underlying interrelatedness of gross size and function, or whether it has deeper biological roots, in which case Factor_{VI} may reflect incipient mesomorphy. The former explanation appears more plausible.

The second factor (Y) in the second-order analysis is not a distinct one. Since Factors VII and VIII may be error factors, and have been named only tentatively, the relatively high loadings may not be as meaningful as they appear. The loadings on Factors II (power) and V (endurance) suggest that the factor may be related to motor performance.

Discussion

Three types of growth have been isolated, two related to linear growth and one to cross-sectional growth, and a fourth type has been suggested as being possibly related to muscular development. A problem of major concern is to what extent these types reflect permanent characteristics of body build and to what extent transient characteristics. There is ample evidence (13, 17, 27, 42) to indicate that the soft tissues are affected markedly under certain conditions of nutritional and training variations, a situation which led Sheldon (38) to revise his earlier concepts about the permanency of somatotype ratings and to distinguish between the morphogenotype and the morphophenotype. It seems reasonable to assume that where ratings of

body build have been made in physical education, more emphasis has been placed on the phenotypic aspects of build, such as are reflected in the quantity of fat covering and firmness of the muscles, than on the genotypic, and the reverse is probably true of constitutional workers. This involuntary bias presents one of the more subtle hazards of subjective assessments of body type.

The work of Hammond (18), wherein animals of different breeds were made to attain markedly similar adult shapes by variations in caloric intake at various stages of growth, suggests that the somatotype is not wholly determined by heredity. It is indeed possible that two human beings may develop similar adult body builds through the operation of quite dissimilar genes and environmental influences.

Much conceptional confusion exists concerning the origin and development of body build because many constitutional workers have been preoccupied with the autonomous functioning of the germ layers. Stockard (41) has shown the importance of organizer tissues and their role in development. Various tissues are known to act as organizers in sequence, and as Hunt (21) observes, their effects on their surroundings are not confined to one germ layer. Thus, while Sheldon's typology may be adequate descriptively, the basis of its interpretation in terms of three germ layers is not satisfactory.

There is a current trend in constitutional research pointing in the direction of developmental and environmental influences being of more consequence in the determination of adult body build than is commonly supposed. The major determinants of adult build might well be a combination of hereditary influences, exercise, and nutrition. The effect of the last has been crucially tested and found to be of marked consequence (27). No comparable experiments have been conducted with different types of physical training as the experimental variants. This line of research, using children as subjects, would be of value in increasing understanding of the relative contributions of the genotype and phenotype to physique.

The motor variables included in the study have been shown to be, with one exception (strength), relatively free from the influence of morphological variables after general size, or isometric growth, had been partialled out. Since previous studies conducted along developmental lines have shown consistent improvements in many abilities with age and general growth, the logical inference has been that physical abilities and hereditary influences proceed cheek by jowl. The results of the present analysis indicate that the degree of intimacy is less than supposed. In this connection, a noteworthy point is that Factor V, reflecting endurance, is essentially unrelated to either isometric or allometric growth, and this is consistent with the oxygen intake data of Åstrand, Robinson, and Morse, and others.

Where relationships have been shown between age and performance, one might assume that a combination of growth, developmental, and environmental influences are responsible, but in the case of growth, it is clear from the results of the present study that size rather than shape is more important.

Summary

Three growth trends were observed in the physique of prepubescent boys:
1. One related to growth in transverse directions and adipose tissue, and characterized by bulkiness, prominent girths (particularly of the upper arms), broad hips, narrower shoulders, and thick fat covering.
2. One related to growth in vertical dimensions, and characterized by a lean frame and attenuated limbs.
3. One related to dysplastic growth in vertical dimensions, and characterized by disproportionate development of the trunk and legs.

Two further growth factors were isolated and tentatively named:
1. One may be related to asymmetrical development of the upper and lower limbs.
2. The other may be related to andric and gynic growth, leading in this age group to wide shoulders and narrow hips, or conversely, narrow shoulders and wide hips.

Three factors related to motor ability were isolated:
1. Power dominated by jumping events, and distinguishing those with high from those with low ability to handle the body weight.
2. Endurance, distinguishing individuals with high, from those with low, organic efficiency.
3. Dynamic shoulder strength, which separates those with high muscular endurance in activities requiring strength of the shoulders, from those with low muscular endurance. This factor was more closely related to the morphological variables than was the case with the other two motor fitness factors, and may be related to muscular growth.

Two second order factors were extracted:
1. General size, differentiating between those who are above and those below average in total body mass.
2. An unidentified factor that may be related to general motor ability.

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Effect of Water Balance on Ability to Perform in High Ambient Temperatures[1]

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Abstract

To determine the effects of water balance on ability to perform in high temperatures, 18 male subjects were subjected to exhaustion runs on the treadmill under three experimental conditions: normal water balance, dehydration, and superhydration. All three runs were performed in an ambient temperature of 120°F. No statistical difference was found between performance under conditions of superhydration and normal water balance, but performance in the dehydrated state was significantly reduced.

The performance of a subgroup of 11 athletes under the condition of superhydration was significantly superior to their corresponding performance under the condition of normal water balance. The seven nonathletes did not exhibit this tendency.

ATHLETES PERFORMING in hot and humid environments frequently lose 3–7 percent of their body weight during an athletic contest or practice session. This loss of water and electrolytes may lead to an immediate reduction in physiological efficiency; if dehydration becomes acute, heat cramps, heat exhaustion, or heat stroke may follow. One of the purposes of this study was to determine whether any significant reduction in work performance accompanies dehydration of the magnitude of a 3 percent loss of body weight.

A second purpose of this study was to test the hypothesis that the ingestion of large quantities of saline solution immediately preceding physical activity in hot environments would be to the physiological advantage of the athlete and would not result in a reduction in his work performance. This hypothesis stems from the work of Adolph and others (2) who state:

> To a small extent man can anticipate a period of water privation by priming the body with extra water. This water is retained over a considerable period of time, since to eliminate the excessive intake by excreting more urine requires two or three hours. Therefore he can to advantage fill his stomach with an amount of water which will last for that period of time.

Since the average athletic contest or practice session normally terminates within this two- to three-hour limit, it was hypothesized that the ingestion of quantities of saline solution immediately preceding the beginning of physical activity in hot environments would be to the physiological advantage of the athlete.

Review of Literature

A study conducted in this laboratory in 1949, by Little, Strayhorn, and Miller (6), suggested that the ingestion of 1.0 to 1.5 liters of water five minutes preceding exercise

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"had no adverse effect on heart rate and minute volume of ventilation during treadmill running nor on performance time in swimming and track events."

Blank (3) did a study of 33 collegiate track and field men running 220-yard time trials under conditions of (a) no liquids in the hour preceding the time trials, (b) the ingestion of one pint of water five minutes before the time trials, and (c) a condition of free water consumption preceding the time trials. He accepted the null hypothesis relative to the influence of water ingestion on performance in 220-yd. time trials.

Dehydration exhaustion is a term used by Brown (4) to describe a condition of exhaustion in which the major debilitating factor is a deficit of body water. He further reported that "work alone was generally insufficient to initiate collapse. But once dehydrated, the man did not recover much of his ability to work by resting or by cooling off in a temperate atmosphere." Dehydration was thus demonstrated to play a major role in exhaustion in hot environments.

Method

The present study differed in part from previous studies in that it employed saline solution and was performed at extreme temperatures. The dehydration part of this study was the first step in a systematic investigation of the effects of varying degrees of dehydration on physical performance.

The 18 subjects used in this experiment were varsity athletes, physical education instructors, and students enrolled in the required physical education program. The first five columns of Table 1 present data describing the 18 subjects. The percent of fat reported in this table was determined by measuring skinfolds and using the Brozek and Keys' nomogram (5). The step test was the rapid form of the Harvard Fatigue Laboratory Test of Physical Fitness.

The subjects were exercised to exhaustion under three experimental conditions. The exhaustive bout of exercise common to all three conditions required each subject to run seven miles per hour up an 8.6 percent grade in a temperature of 120° F until he indicated that he was exhausted by removing himself from the treadmill. The experimental conditions related to water balance. Under the first condition each subject ingested one liter of isotonic saline and one liter of water in the 30-minute period preceding the exhaustion run. The second condition required each subject to lose 3 percent of his body weight in the 24-hour period preceding the exhaustion run. This weight loss was accomplished by deprivation of water during the 24-hour period coupled with alternate 30–45 minute periods of sitting in a temperature of 120° F wearing sweat clothes. The third condition was a control condition in which subjects performed the exhaustion run under the condition in which they entered the laboratory. Their thirst mechanism was relied upon to bring them to their normal water balance.

A .450 percent saline solution was arbitrarily prescribed for the superhydrated condition. The sodium concentration, therefore, was about one-half that of normal body fluids and from two to four times as great as in sweat. To facilitate drinking, the first liter given the subject was isotonic saline, and the second was plain water. Previous experience in this laboratory has demonstrated this method of ingesting saline solution to be more palatable to the subjects.

TABLE 1.—DESCRIPTION AND PERFORMANCE SCORES OF THE EIGHTEEN SUBJECTS

Subjects' Description	Age	Height in Centimeters	Pre-experiment Weight in Kilograms	% Fat	Step Test	Exhaustion Time Following the Ingestion of Two Liters of Liquid (Sec.)	Exhaustion Time Under Normal Water Balance (Sec.)	Exhaustion Time Following the Loss of 3% of the Body Weight (Sec.)
Varsity Football Players								
1	19	182.88	126.55	31	30	319	304	308
2	19	185.42	99.34	23	55	1373	955	824
3	20	182.88	96.16	14	55	736	706	416
4	18	177.80	90.27	10	105	1277	1241	818
5	21	180.34	92.99	14	95	1033	1018	771
6	19	185.42	94.80	19	95	1115	994	665
Freshman Basketball Player								
7	18	182.88	73.48	8	130	1128	1074	661
Graduate P.E. Instructors								
8	23	177.80	82.10	10	95	1637	1587	1127
9	25	172.72	76.21	11	90	1317	1188	1149
10	27	177.80	77.57	12	95	855	749	568
11	29	177.80	71.67	13	75	1680	1456	1337
Students in Required P.E.								
12	18	175.26	97.98	26	30	519	475	480
13	18	175.26	61.69	10	80	1538	1852	756
14	21	177.80	73.03	9	55	1053	1297	751
15	19	175.26	118.39	36	25	243	253	214
16	18	167.64	101.61	28	50	699	747	494
17	28	175.26	67.58	11	30	1027	860	607
18	25	172.72	69.40	8	80	1133	1463	1090
Mean	21.39	177.93	87.27	16.28	70.56	1037.89	1012.17	724.72
Standard Deviation	3.68	5.11	17.31	8.47	29.66	404.80	423.65	294.54
Coefficient of Variation						39.00	41.86	40.67

All subjects received the same instructions and motivations from the experimenter. They were instructed to run as long as possible and then were taken to the heat chamber. The subjects were observed through a glass window and had no further interactions with the experimenter until they indicated that they were exhausted by stepping off the treadmill. The subjects were not aware of how long they had run under any of the conditions.

To minimize the conditioning effects of the three runs, the subjects were randomly assigned to the three experimental conditions. The experiment was conducted over a three-month period, but each subject completed his trials in three consecutive days. The subjects received no preliminary training or acclimatization.

In order to appraise the physiological effects of the three conditions of water balance, the following data were collected during each run:

Water loss. Water loss represented the difference between the subjects's nude weight before and after the exhaustion runs, measured on scales accurate to ten grams.

Increase in heart rate. The subject's resting heart rate was determined, preliminary to the exhaustive runs, by stethoscope after the subject reclined for ten minutes. The difference in this rate and his heart rate immediately following exercise represented his increase in heart rate.

Increase in rectal temperature. Increase in rectal temperature represented the difference between the subject's rectal temperature five minutes before the run and that immediately following the run. Rectal temperature was monitored continuously throughout the run by use of a telethermometer.

Comparison of Superhydrated, Control, and Dehydrated Conditions

Comparison of the above measures from condition to condition was difficult as a result of the great variability in exhaustion times between the conditions. In order to make equitable comparisons linearity was assumed between running time and the three stress measures. This is open to question, but was considered permissible for comparison of subjects with themselves under varying conditions. Under this assumption, the three stress measures were divided by exhaustion time under the three conditions to determine the rate of water loss, rate of increase in heart rate, and rate of increase in rectal temperature.

The differences between mean performances in the conditions of superhydration and control water balance are presented in Table 2. The exhaustion times did not differ significantly between the two conditions. The mean for the superhydrated condition was slightly higher, but this difference did not reach significance at the .01 level of confidence, which was the level accepted for this study. An appraisal of the physiological condition of the subjects following exhaustion revealed no significant differences between the two conditions. The mean increase in heart rate was a little slower in the superhydrated state, but this advantage was not significant at the .01 level. Neither the rate of increase in rectal temperature nor the rate of water loss differed significantly between the two conditions.

It has been demonstrated in this laboratory that superhydration provides a definite physiological advantage for subjects working in a temperature of 110° F for three hours (1). The fact that the subjects demonstrated no physiological advantage in the superhydrated state in the present study was attributed to the short time in which they reached exhaustion—the longest time being 28 minutes. The significant finding of the present investigation was that superhydration in the amount of two liters of fluid did not reduce performance.

As compared to the control condition, a 28 percent reduction in exhaustion time was found to accompany dehydration of the magnitude of a 3 percent loss in body weight. This reduction was significant beyond the .01 level. A significantly faster increase in heart rate was found to accompany the dehydrated condition. This increase was significant beyond the .01 level. Mean water loss was less in the dehydrated state and approached significance at the .01 level. The rate of increase in rectal temperature did not differ significantly between these two conditions. The differences between mean performances for the conditions of dehydration and control water balance are presented in Table 2.

Essentially the same differences were found to exist between superhydration and dehydration as between dehydration and control water balance. In the former case, however, the differences were more pronounced, as may be seen in Table 2.

The variability of performance under the three experimental conditions was found to be approximately equal. The coefficients of variation are presented in Table 1.

Response Patterns of Athletes and Nonathletes Under the Three Experimental Conditions

For purposes of further analysis, the 18 subjects were divided into an athletic and nonathletic group. The athletic group consisted of six varsity

TABLE 2.—SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS UNDER SUPERHYDRATED, DEHYDRATED, AND NORMAL WATER BALANCE CONDITIONS

	Superhydration	Dehydration	Normal	Mean Differences	Probability
Exhaustion Time	1037.89 sec.		1012.17 sec.	25.72 sec.	$P > .01$
	1037.89 sec.	742.22 sec.		295.67 sec.	$P < .01$
		742.22 sec.	1012.17 sec.	269.95 sec.	$P < .01$
Rectal Temperature	.091°C.		.090°C.	.001°C.	$P > .01$
Increase per Minute	.091°C.	.070°C.		.021°C.	$P > .01$
		.070°C.	.090°C.	.020°C.	$P > .01$
Water Loss per Minute	43.66 g.		39.12 g.	4.54 g.	$P > .01$
	43.66 g.	35.44 g.		8.22 g.	$P > .01$
		35.44 g.	39.12 g.	3.68 g.	$P > .01$
Average Increase in	8.51		8.96	.45	$P > .01$
Heart Rate	8.51	11.52		3.01	$P < .01$
per Minute		11.52	8.96	2.56	$P < .01$

football players, one freshman basketball player, and four graduate physical education instructors who were athletes of one year past. The nonathletic group consisted of students enrolled in required physical education with no experience on either freshman or varsity athletic teams.

The purpose of dividing the 18 subjects into an athletic and a nonathletic group was to determine the relative effects of the three conditions on the two groups. Table 3 presents the effects of the experimental conditions on the athletes and nonathletes, considered independently. No attempt was made in this study to compare directly the performance of athletes and nonathletes.

In regard to the three experimental conditions, superhydration was the only condition that affected the athletes and nonathletes differently. The mean exhaustion time of the athletes under superhydration was 1134 seconds as compared to a reduced time of 1025 seconds in the control condition. The mean difference of 109 seconds was significant beyond the .01 level of con-

TABLE 3.—PERFORMANCES OF ATHLETES AND NONATHLETES UNDER SUPERHYRATED, DEHYDRATED, AND NORMAL WATER BALANCE CONDITIONS

	Super-hydration	Dehydration	Normal	Mean Differences	Probability
Exhaustion Time	1134 sec.		1025 sec.	109 sec.	P < .01
of Athletes	1134 sec.	786 sec.		348 sec.	P < .01
		786 sec.	1025 sec.	239 sec.	P < .01
Exhaustion Time	887 sec.		992 sec.	105 sec.	P > .01
of Nonathletes	887 sec.	627 sec.		260 sec.	P < .01
		627 sec.	992 sec.	365 sec.	P < .01
Rectal Temperature	.09°C		.09°C.	.00°C.	P > .01
Increase per Minute	.09°C	.10°C.		.01°C.	P > .01
of Athletes		.10°C.	.09°C.	.01°C.	P > .01
Rectal Temperature	.08°C.		.06°C.	.02°C.	P > .01
Increase per Minute	.08°C.	.08°C.		.00°C.	P > .01
of Nonathletes		.08°C.	.06°C.	.02°C.	P > .01
Water Loss per Minute	48.76 g.		42.24 g.	6.52 g.	P > .01
of Athletes	48.76 g.	37.42 g.		11.34 g.	P > .01
		37.42 g.	42.24 g.	4.82 g.	P > .01
Water Loss per Minute	36.00 g.		39.69 g.	3.69 g.	P > .01
of Nonathletes	36.00 g.	32.04 g.		3.96 g.	P > .01
		32.04 g.	39.69 g.	7.65 g	P > .01
Average Increase in	7.50		8.51	1.01	P > .01
Heart Rate	7.50	10.65		3.15	P > .01
per Minute		10.65	8.51	2.14	P > .01
of Athletes					
Average Increase in	9.95		9.66	.29	P > .01
Heart Rate	9.95	12.89		2.94	P < .01
per Minute of		12.89	9.66	3.23	P < .01
Nonathletes					

fidence. Not only was this difference significant, but without exception all 11 athletes had longer exhaustion times under the superhydrated condition (see Table 1).

The pattern of response in the nonathletes was different from that found in the athletic group. The exhaustion time of nonathletes under the superhydrated condition was 887 seconds as compared to a longer time of 992 seconds under the control condition. This difference of 105 seconds was not significant at the .01 level of confidence.

The heart rates, rectal temperatures, and sweat losses of the athletes and nonathletes were not affected differently by the three experimental conditions. Table 3 presents the significance of the differences between the means of these measures for the athletes and nonathletes under the experimental conditions.

Summary and Conclusions

The purpose of this study was twofold. First, it was designed to determine whether any significant reduction in work performance accompanied dehydration of the magnitude of a 3 percent loss of body weight. A significant decrement was demonstrated. Secondly, the study was designed to test the hypothesis that the ingestion of large quantities of saline solution immediately preceding physical activity in hot environments would be to the physiological advantage of the athlete and would not result in a reduction in his work performance. A group of 18 subjects (11 athletes and 7 nonathletes) demonstrated no physiological advantage following the ingestion of saline solution preliminary to work in the heat. The second part of the hypothesis was supported in that no significant reduction in performance was found to be associated with the ingestion of two liters of saline solution immediately preceding work even though the work was strenuous enough to result in exhaustion in less than 30 minutes. In the case of the athletes, a significantly increased exhaustion time was found to accompany the superhydrated condition.

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Investigation of the Relationship of Hand Size and Lower Arm Girths to Hand Grip Strength as Measured by Selected Hand Dynamometers[1]

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Abstract

This study explored the relationship of certain characteristics of the hand and forearm to hand grip strength as measured by adjustable and nonadjustable types of dynamometers. It was found that the measurements of the length of the hand and fingers and forearm girths were significantly related to hand grip strength. First order partial correlations, with weight held constant, changed the significance of only one of the relationships; the correlation between hand length and grip strength scores registered on the Naragansett hand spring dynamometer. A comparison of the means of the scores obtained on each of the three dynamometers, the Stoelting adjustable dynamometer, the cable tensionmeter, and Naragansett hand spring dynamometer, showed a significant difference only between the cable tensiometer and the Naragansett hand spring dynamometer.

HAND GRIP STRENGTH TESTS are an integral part of strength test batteries and have been used as a measure of physiological growth and physical fitness. Through research, the anatomical structure and kinesiological principles involved in gripping with the hand are well known, but little research has been conducted to explore the factors contributing to hand grip strength.

Many studies have utilized hand grip strength tests, but only three were discovered which investigated factors relating to hand grip strength or compared the results of the adjustable and nonadjustable types of hand dynamometers. Griffith (3) reported that the scores recorded by 11 subjects on the Smedley adjustable dynamometer were from 19 to 63 percent higher than the scores registered by the same individuals on the Collins elliptical dynamometer. The differences registered on the two instruments varied from subject to subject but not in any definite pattern. He concluded that recorded grip strength depended on the instrument used to measure it. Everett and Sills (2), in a study involving 400 subjects 14 to 29 years old, found coef-

[1] This study was made in partial fulfillment of an M. A. degree in the College of Physical Education, Recreation, and Health, University of Maryland, Benjamin H. Massey, advisor. The writer wishes to express his sincere appreciation to George F. Kramer for his invaluable assistance in the Physical Education Laboratory.

ficients of correlation of .63 hand width, .50 hand length, and .49 finger length with hand grip strength as measured by a nonadjustable Naragansett dynamometer. On the other hand, Burke (1), in a study using 30 male adults aged 20 to 84, found a .21 coefficient of correlation between length of the hand and hand grip strength measured by a nonadjustable strain gauge dynamometer.

The Problem

The discrepancies concerning the relationship of hand size to grip strength and the need for data resulting from studies using adjustable hand dynamometers warranted further research in this area. Specifically the objectives were to (a) discover the statistical relationship between the length of the hand and fingers and hand grip strength scores registered on a nonadjustable Narragansett hand spring dynamometer and scores obtained from the Stoelting adjustable hand dynamometer and cable tensiometer when adjusted to individual hand size, (b) compare hand grip strength scores registered by the same individual on the adjustable and nonadjustable types of dynamometers, and (c) investigate the relationship of such factors as hand width, forearm girth, wrist girth, height, body weight, and age to hand grip strength.

Procedure

One hundred volunteer subjects were obtained from five required physical education classes at the University of Maryland. The ages of the subjects ranged from 18 to 24 years; their mean age was 19 years, 3 months.

All anthropometrical measurements were taken at one sitting with one recording for each measurement. The measurements, which were taken on the dominant hand, were of hand length, middle finger length, first phalanx of the middle finger length, and hand width. All were measured with a sliding caliper and recorded to the nearest tenth of a centimeter. The base of the sliding caliper was placed on the appropriate point, as shown in Figure I, for each measurement and the sliding bar adjusted according to the subject's hand size. Included also were measurements of the subject's dominant forearm and wrist girths and height and weight. The wrist and forearm girth measurements were made with the subject's arm extended and the muscles of the forearm statically contracted. Wrist girth measurements were obtained by measuring the circumference of the wrist at points A and B, Figure I, with an anthropometrical tape. The tape was also used to obtain forearm girth measurements, which were taken at the largest part of the subject's forearm. Height and weight measurements were taken in physical education uniforms without shoes. Height was recorded to the nearest tenth of an inch and weight to the nearest quarter of a pound.

The reliability of each of the anthropometrical measurements was checked by taking a random sample of 45 subjects and remeasuring them within one week of initial measurement. The raw scores of the first and second measurements of the 45 subjects were correlated using the Pearson product-moment method. A t ratio of the significance of the difference of the means of both

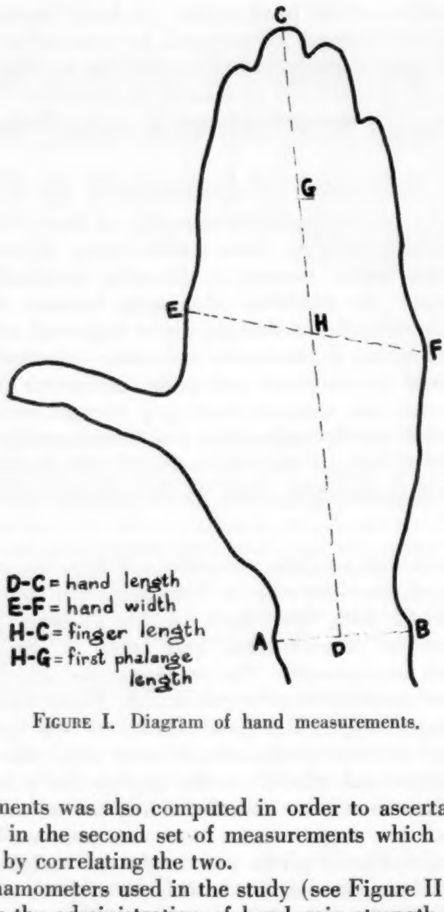

FIGURE I. Diagram of hand measurements.

sets of measurements was also computed in order to ascertain if any change had taken place in the second set of measurements which would not necessarily be shown by correlating the two.

The three dynamometers used in the study (see Figure II) were calibrated before and after the administration of hand grip strength tests by hanging known weights on them. The dynamometers were suspended from the ceiling by straps, and iron weights were hung so as to exert pressure on the handles like that which occurs in gripping the dynamometer. Weight was exerted in equally distributed increments of five pounds and readings were taken by the author after the addition of each weight. Two calibrations of each dynamometer were made before and after the grip strength testing period and no change in the dynamometers was found to have taken place during the six-week testing period. The calibration of each dynamometer was used to establish tables, to correct readings, and to convert all readings to pounds.

The hand grip strength of all 100 subjects was tested on three different types of hand dynamometers—the Naragansett hand spring dynamometer,

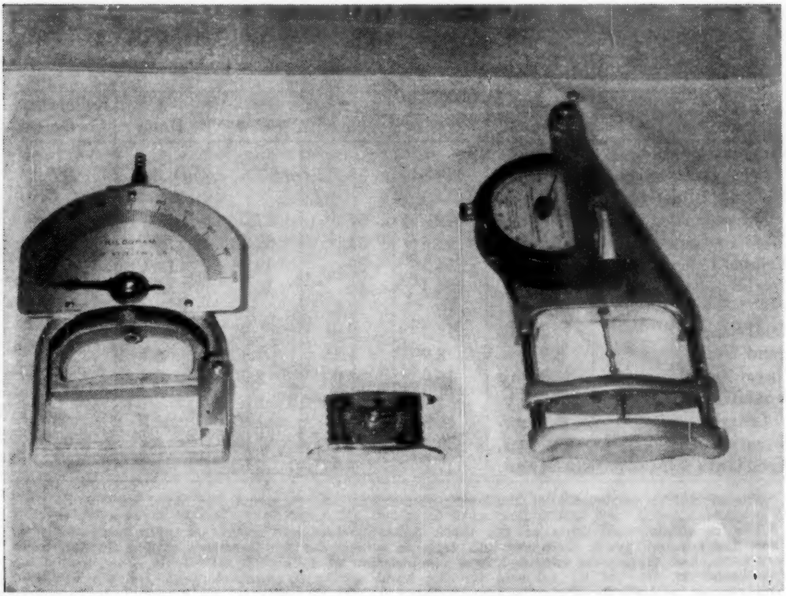

FIGURE II. The Stoelting adjustable dynamometer, the Naragansett hand spring dynamometer, the cable tensiometer.

the Stoelting adjustable spring type dynamometer, and the cable tensiometer. During each visit to the Physical Education Laboratory, subjects were given two grip strength trials on the same dynamometer with a five-minute rest between each trial. After six visits, each subject had four grip strength scores registered on each of the three dynamometers. All grip strength tests were administered during a six-week period with the mean time for each subject being three weeks. The testing schedule was arranged so that there would be at least 48 hours between each test and so that the test would be taken before subjects had participated in any vigorous activity that day. A uniform adjustment of the cable tensiometer and the Stoelting adjustable dynamometer according to the length of each subject's palm was used throughout the study. The administration of the grip strength tests followed basically the same procedure for all of the three types of dynamometers. Each subject's final grip strength score on each dynamometer was a result of averaging his four grip strength trials.

Results and Discussion

Statistical analysis of the data (see Table 1) showed that all reliability coefficients of the anthropometric measurements were .95 and above. No significant difference was found to exist between the means of the initial measurements and the remeasurements.

TABLE 1.—MEANS, STANDARD DEVIATIONS, t RATIOS, AND RELIABILITY COEFFICIENTS OF HAND GRIP STRENGTH TESTS AND ANTHROPOMETRICAL MEASUREMENTS [a]

	m_1	m_2	σ_1	σ_2	t Ratio	Reliability Coefficient
Naragansett Hand Spring Dynamometer	116 lbs.	119	55.7	57.5	.30	.89[b]
Stoelting Adjustable Dynamometer	119 lbs.	122	57	57.9	.39	.91[b]
Cable Tensiometer	112 lbs.	113.5	51	52.8	.43	.94[b]
Weight	153.7 lbs.	154.5	18	19.2	1.69	.99
Height	105.3 ins.	104.4	16	16	.01	.99
Age	19.3 yrs.		7.6			
Hand Length	19.2 cms.	19.3	2.91	2.92	.75	.97
Hand Width	8.9 cms.	8.9	1.35	1.35	.03	.95
Finger Length	16.8 cms.	16.9	2.6	2.7	.06	.96
Proximal Phalanx Length	6.9 cms.	6.8	1.04	1.03	.11	.96
Forearm Girth	28.2 cms.	28.1	1.27	1.26	.65	.99
Wrist Girth	17.4 cms.	17.2	2.63	2.60	.23	.95

[a] The reliability coefficients of the anthropometrical measurements are based on the data of 45 subjects.

[b] The reliability coefficients of the three dynamometers are based on grip strength trials taken five minutes apart. Grip strength tests in which the dynamometer slipped in the hand were noted and these were excluded from computation of reliability coefficients, thus coefficients were based on data of 91 subjects for the hand spring dynamometer, 98 for the Stoelting dynamometer, and 99 for the cable tensiometer.

Reliability coefficients of .94 for the cable tensiometer, .91 for the Stoelting adjustable dynamometer, and .89 for the hand spring dynamometer were found when the subjects' grip strength scores in Trial I were correlated with those of Trial II taken on the same day with a five-minute rest between the two. The t ratio showed that there was no significant difference between the means of grip strength Trials I and II.

The correlations (see Table 2) showed that each of the factors—length of hand, length of middle finger, and length of the proximal phalanx of the middle finger—was significantly related to hand grip strength. These findings compared closely with the .49 correlation between the length of the fingers and hand grip strength found in the study by Everett and Sills. It is interesting to note that all of the correlations involving length of the hand and fingers are slightly higher on the adjustable dynamometers than on the nonadjustable dynamometer. This seems to indicate that adjusting the dynamometers improved the possibility of the subject's registering grip strength scores relative to his hand and finger lengths. Perhaps the adjustment permitted an individual to take full advantage of his leverage and, therefore, the adjustable dynamometer more nearly reflects true hand strength.

The correlation of the factors of forearm girth, wrist girth, hand width, body weight, and height with hand grip strength as measured by each of the three dynamometers were all significant at the 1 percent level of confidence; only the correlation of age with hand grip strength failed to reach

TABLE 2.—ZERO ORDER AND FIRST ORDER PARTIAL CORRELATIONS OF FACTORS RELATED TO HAND GRIP STRENGTH [a]

	Naragansett Hand Spring Dynamometer		Stoelting Adjustable Dynamometer		Cable Tensiometer	
Factors	Zero Order Coefficients	First Order Partial Coefficients[b]	Zero Order Coefficients	First Order Partial Coefficients[b]	Zero Order Coefficients	First Order Partial Coefficients[b]
Forearm Girth	.58	.50	.64	.59	.57	.47
Wrist Girth	.52	.41	.60	.50	.56	.46
Proximal Phalanx Length	.46	.39	.54	.48	.55	.50
Finger Length	.41	.32	.49	.37	.48	.46
Hand Width	.40	.31	.44	.35	.44	.31
Hand Length	.31	.22	.41	.33	.42	.35
Weight	.35		.39		.36	
Height	.27		.29		.31	
Age	.24		.21		.20	

[a] The zero order and first order partial correlations are based on the data of 100 subjects.
[b] In the first order partial correlations the factor of body weight was held constant.

significance. The high correlations of forearm and wrist girths with hand grip strength are not surprising, since the flexor and extensor muscles which account for hand grip strength are located in the forearm and pass over the wrist to the fingers.

The mean of the scores registered on the hand spring dynamometer was 122 lbs.; on the Stoelting adjustable dynamometer, 117 lbs; and on the cable tensiometer, 110 lbs. A comparison of the means of the scores registered by subjects on each of the three dynamometers, using a t ratio, showed a significant difference at the 5 percent level of confidence only for the difference between scores obtained on the hand spring dynamometer and on the cable tensiometer.

The correlation of weight and hand grip strength, for each of the three dynamometers, was considerably lower than the .66 correlation coefficient between weight and hand grip strength found by Everett and Sills.

Body weight, when held constant by means of a first order partial correlation, changed only one correlation; the correlation between hand length and grip strength scores registered on the Naragansett hand spring dynamometer was no longer significant at the 1 percent level.

It appears that the selected method of adjusting the dynamometer according to the size of the palm was not necessarily the best method of adjustment to obtain an individual's highest grip strength score. The high correlation between the length of the proximal phalanx of the middle finger and hand grip strength suggests this factor should be taken into consideration in adjusting the dynamometer.

Conclusions

1. Adjustment of the dynamometers according to the length of the palm appears to enable an individual to register hand grip strength scores more nearly related to the lengths of the hand and middle finger.

2. The only significant difference found between scores obtained on the nonadjustable and adjustable types of dynamometers was between scores registered on the hand spring dynamometer and the cable tensiometer.

3. Forearm girth, wrist girth, proximal phalanx of the middle finger length, hand width, hand length, body weight, and height were all found to be significantly related to hand grip strength, but one factor alone cannot be singled out as being predictive of hand grip strength.

4. Although body weight is related to hand grip strength and to certain hand and lower arm measurements, it does not relate highly enough to change appreciably the correlation coefficient between the measurements of lower arm girth and grip strength.

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Neuromotor Specificity and Increased Speed from Strength Development[1]

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Abstract

Arm strength, effective arm mass, and speed in a lateral adductive arm movement were measured in 62 college men and remeasured ten weeks later. During this interval, half of the subjects were given weight training exercise that did not involve the movement, while the other half remained inactive in order to provide a control group. The average of the training group improved significantly in speed, strength, and strength/mass ratio, whereas the average of the control group declined. There was no correlation between individual differences in speed and strength/mass ratio, but individual changes in the ratio correlated significantly ($r = .405$) with individual changes in speed. Reaction time was not improved by weight training.

SPEED IS THE RESULT of a physical force that acts on a mass. In the field of human movement, the mass is the body or one of its limbs, and the force is the muscular strength that is exerted by the individual on the mass that is moved. Recent studies from this laboratory have emphasized that individual differences in strength are highly task-specific. It has been found that the strength of a limb, as measured statically with a dynamometer, has little or no correlation with the strength exerted on the limb during a movement made at maximal speed (1, 3, 4, 8).

Problem Investigated

Even though neuromotor specificity is so great that there is little or no correlation between static dynamometer strength and speed of movement (which is the reult of strength in action), there is a possibility that the speed of a movement can be increased by strengthening per se the muscles which cause that movement (3). To investigate the basic aspect of this problem, it is necessary to develop strength by some method that avoids practicing the test movement, in order to exclude the possibility that the anticipated increase might simply be the result of improved neuromotor skill. We have investigated this problem, using weight training to develop strength and testing an arm movement that was not explicitly exercised in the training program. As a secondary interest, we have secured data to answer the question of whether the increased speed that may result from the strengthening exercise is associated with any increase in the quickness of the reaction that initiates the movement.

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1 From the Research Laboratory of the Department of Physical Education. This study was supported by a grant from the Faculty Research Fund of the University of California.

Methodology

Subjects and Experimental Design. Two groups of subjects were tested. The unexercised group (designated controls) included 31 college men, volunteers from compulsory military science courses. They were given merit points for completing the experiment. All of these men refrained from participating in athletics, physical education classes, or other systematic developmental activities during the semester that they were under test. The experimental group consisted of 31 college men, members of nonrequired elementary weight-training classes who had volunteered for the experiment. The exercises they were given will be described later. The movement chosen for investigation was the horizontal adductive arm swing that we have used in previous studies. This movement has been found to give reliable results and permit accurate measurement of the effective mass, strength, and speed.

At the start of the college semester, 12 trials were given on the reaction time and speed of movement test, but only the last eight were used in the computations in order to reduce possible practice effects. Three strength tests were performed and averaged, six arm mass measurements were obtained and averaged, and the strength-mass ratios (s/m) were computed for each subject. The reason for using this ratio rather than raw strength is that speed (i.e., arm movement) depends on the ratio of force to mass as was explained in a previous article (4).

Ten weeks later the tests were repeated exactly, duplicating the hour and day of the original test. During this ten weeks the experimental group was exercised and the control group was inactive. The experimental design therefore permitted the computation and statistical evaluation of the possible gains in s/m ratio and speed of movement, utilizing the control group to establish that the gains in speed were not the result of practice (i.e., experience in performing the tests). In addition, and independent of any formal classification of subjects as to group, the design supplied a sample of bivariate changes in s/m and MT suitable for correlational analysis, as will be explained later. Note that the type of exercise responsible for the changes is only of secondary interest.

Exercise. Subjects in the experimental group were members of regular weight-training classes that met twice a week. The classes were taught or directed by one of the authors. The net time of active exercise was 35 minutes per class period. The exercise done each period consisted of a routine of specified training activities designed to increase muscular strength of the upper and lower extremities. Because of the nature of the class, particular attention was paid to strengthening of the arms and shoulder girdle. A series of progressive resistance exercises was used, based upon the system of ten repetitions maximum as advocated by DeLorme (2). There was no practice of the movement used in the speed test, or the strength test, during the ten-week interim between test and retest.

Apparatus and procedure. For the arm speed test, the subject rested his laterally extended right arm on a reaction key adjusted to shoulder height. In

response to an auditory stimulus, he swung his rigid arm leftward at maximal speed past the median position where the hand touched a vertical string that operated the timing key. Two chronoscopes were used, so that both net reaction time and net movement time were recorded. The arm distance traversed by the reference point (the metacarpophalangeal joint) was 117 cm. for all subjects, corresponding to 110 degrees of arc for the average person. This movement was the same as that used in the Henry and Whitley Experiment II (4).

Right arm lateral adductive strength, arm length, and effective arm mass were measured in the movement position, using the methods described by Clarke (1). The average values of these measures are given in later tables, except for the arm length, which was 60.5 cm. ($\sigma = 3.65$) in the experimental group and 60.6 cm. ($\sigma = 2.57$) in the controls.

TABLE 1.—RELIABILITY COEFFICIENTS

Factors	Experimental		Control	
	raw	corrected	raw	corrected
Strength (s)	.898	.946	.923	.960
Mass (m)	.928	.963	.949	.974
Movement (MT)	.918	.958	.861	.926
Reaction (RT)	.836	.911	.838	.912

Results

Reliability of Individual Differences. The reliability coefficients have been computed for the initial test by the odd-even method and corrected to the full-test values by the Spearman-Brown formula. Individual differences in all measures exhibit satisfactory reliability, as may be seen in Table 1. Coefficients for the s/m ratio have not been calculated. It may be assumed that they are at least as high as for strength, since this was found to be the case in both of the Henry-Whitley experiments (4).

Gains from Exercise. The means and standard deviations for the various measures, as well as the t values for the gains during the ten-week period, are given in Table 2. There was no appreciable change in either group of subjects in arm mass or in reaction time; the t values range from zero to 1.3, and even the highest of these is well below statistical significance at the 5 percent level. Reaction time will therefore receive no further analysis in this study.

In the control group, both strength and the s/m ratio declined 8.7 percent, which is a statistically significant reduction since the t values are 4.3 and 4.4. Although the movement time increased, the mean change was not significant ($t = 0.8$). We have no explanation to offer for the decline in strength, other than physical inactivity. The subjects seemed to be well motivated in both Test I and Test II, and they had been given an incentive to complete the test to the satisfaction of the authors.

TABLE 2.—DESCRIPTIVE STATISTICS

	Experimental		Control	
	M	σ	M	σ
Strength (kg)				
Test I	16.04	2.53	18.04	2.75
Test II	18.91	2.19	16.79	3.09
Gain	2.87	1.59	—1.25	1.60
t	9.88[a]		4.27[a]	
Mass (kg)				
Test I	1.061	0.233	1.033	0.220
Test II	1.056	0.208	1.052	0.209
Gain	—0.005	0.088	0.019	0.083
t	0.31		1.26	
Ratio (s/m)				
Test I	15.40	4.74	18.06	3.71
Test II	18.82	4.68	16.49	3.95
Gain	3.42	3.36	—1.57	1.97
t	5.51[a]		4.36[a]	
Movement (Sec.)				
Test I	0.192	0.023	0.199	0.020
Test II	0.184	0.024	0.202	0.024
Gain	—0.008[b]	0.015	0.003[b]	0.021
t	2.87[a]		0.79	
Reaction (Sec.)				
Test I	0.216	0.028	0.235	0.034
Test II	0.216	0.025	0.232	0.038
Gain	0.000	0.028	—0.003	0.039
t	0.00		0.42	

[a] Statistically significant. A t value of 2.04 is required for the 5 percent level.
[b] Gains in speed are indicated by a negative sign in movement time.

In the experimental group there was a 17.9 percent gain in strength, which corresponds to 1.2 z score units. Presumably this was caused by the class exercises, although unscheduled activities cannot be excluded with certainty. Both this increase and the gain in s/m ratio are significant, since the t values are 9.9 and 5.5. Improvement in movement time is also significant ($t = 2.9$), although relatively small since the change is only 4.2 percent, or in z score units, 0.35.

Correlations between Changes in Strength and Speed. In the experimental group, individual changes in the s/m ratio exhibit a significant relationship with changes in movement time. The coefficient is $r = .423$, which is larger than the value required for the 5 percent level of significance (.355). However, in the control group, where the changes in MT and the s/m ratio are much less, the correlation is only .203 and is not significant.

Since the control group exhibited a significant loss in s/m ratio during the semester (although less in amount and variability than the gain of the experimental group), we have combined the two groups in order to secure a more comprehensive analysis of the influence of changes in the s/m ratio on the speed of movement. The cumulative frequency distributions in Figure I

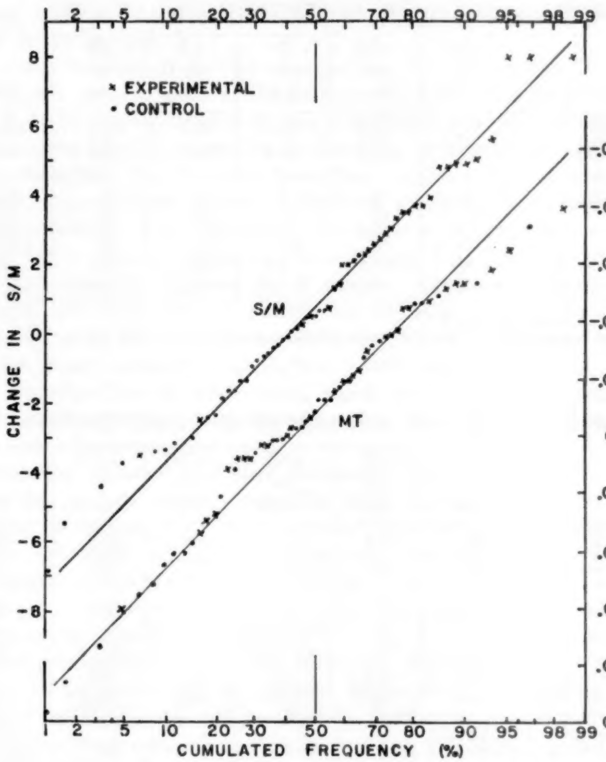

FIGURE I. Frequency distributions of changes in S/M and MT.

show that the gains (or losses) in the total group of 62 subjects form a continuous distribution that is approximately normal and definitely not bimodal for either the s/m ratio or movement time.

The visually fitted trend lines of Figure I define normal distributions having the frequencies designed f_e in Tables 3 and 4. This chi square analysis comparing these with the observed frequencies f_o shows that neither distribution differs significantly from the statistically normal form. The correlation between individual differences in s/m change and MT change is $r = .405$, which is significant since it is well above the criterion value of .250 required for 62 subjects.

Since the data from two different groups have been combined, we must consider the possibility of nonlinear regression of MT on s/m. To investigate this, the scores for the s/m changes have been grouped into 11 class intervals that are 0.9 units wide. The MT change scores corresponding to and thus classified by each one of these s/m intervals constitutes an "array." The

TABLE 3.—NORMALITY OF STRENGTH/MASS CHANGES

Score	−6.0 to −1.7	−1.8 to 0−	0 to 1.7	1.8 to 3.5	3.6 to 8.0	Total
Expected (%)[a]	22.2	18.0	21.0	17.8	21.0	100.0
N expected (f_e)	13.8	11.2	13.0	11.0	13.0	62.0
N observed						
Experimental	2.	0.	5.	1.	12.	31.
Control	12.	12.	6.	12.	0.	31.
Total (f_o)	14.	12.	11.	13.	12.	62.
Difference ($f_e - f_o$)	−0.2	−0.8	2.0	−2.0	1.0	0.
Chi squared (d^2/f_e)	0.00	0.06	0.31	0.36	0.08	0.81[b]

[a] From normal curve hypothesis.
[b] A value of 6.0 is required for 5 percent significance with $k - 3 = 2$ df.

TABLE 4.—NORMALITY OF SPEED OF MOVEMENT CHANGES

Score	5.00 to 1.34	1.35 to 0.14	0.15 to −1.04	−1.05 to −2.24	−2.25 to −3.99	Total
Expected (%)[a]	19.6	19.2	23.0	18.8	19.4	100.0
N expected (f_e)	12.1	11.9	14.3	11.7	12.0	62.0
N observed						
Experimental	4.	6.	7.	7.	7.	31.
Control	9.	3.	11.	3.	5.	31.
Total (f_o)	13.	9.	18.	10.	12.	62.
Difference ($f_e - f_o$)	−0.9	2.9	−3.7	1.7	0.0	0.0
Chi squared (d^2/f_e)	0.07	0.71	0.96	0.25	0.00	1.99[b]

[a] From normal curve hypothesis.
[b] A value of 6.0 is required for 5 percent significance with $k - 3 = 2$ df.

TABLE 5.—VARIANCE ANALYSIS OF LINEARITY OF REGRESSION OF CHANGES IN S/M AND MT

Source of Variance	Analysis			Arrays			
	df	MS	F	s/m	MT[a]	s/m	MT[a]
Total	61	3.776		−3.2	4.10	1.3	7.10
Linear regression	1	34.67	10.6[b]	−2.3	4.23	2.2	5.13
Residuals from line	60	3.261		−1.4	5.00	3.1	6.40
Array means from line	9	1.901	0.5	−0.5	5.34	4.0	6.30
Within arrays	51	3.501		0.4	4.58	4.9	5.76
						5.8	7.08

[a] In units of .01 sec. Note that these are unweighted array means, listed serially. The variance analysis used the sum of individual MT changes in each array. The correlation between s/m and MT array means is .787; between individual raw score differences it is .405.
[b] Statistically significant. The critical value for the 5 percent criterion is 4.1.

resulting 11 arrays have been used to compute a regression variance analysis (6) as shown in Table 5.

The total variance of the MT changes may be divided into "linear regression" of MT on s/m and "residuals from the line" of regression, the latter being the appropriate error term. The resulting F is highly significant, which constitutes statistically acceptable evidence for rectilinear correlation between the two variables. The "residual from line" variance may in turn be divided into its two components, namely, "deviation of array means from regression line" and "within array" variance. The latter is the appropriate error term for the "array means" variance. The resulting F is only 0.5, which is well below the value 2.1 required for 5 percent significance. Thus there is no acceptable evidence for any systematic regression other than the linear component, even though the eta coefficient (.474) seems appreciably higher than the linear correlation coefficient (.388) obtained in the analysis. It should be noted that the latter value, which was necessarily computed by the use of class intervals, is somewhat less than the value .405 reported earlier as the raw score correlation.

Correlation between s/m and Movement Time. This set of correlations utilizes the performance scores rather than changes. Since the MT scores tended to be skewed, they were converted into speed scores. The correlation between individual differences in s/m ratio and speed of movement in the experimental group is found to be .255 for Test I and .322 for Test II. In the control group, the correlation is —.135 for Test I and —.025 for Test II. None of these coefficients differs significantly from zero, since the required value for the 5 percent criterion is .355. Moreover, the signs of the coefficients are opposite in the two groups of subjects. When the two groups are combined, $r = .034$ for Test I and .163 for Test II. Neither of these coefficients differs significantly from zero, since .254 is required for the five percent criterion with 62 subjects. The correlations were also computed using MT without conversion, and were about the same as those given above except that the signs were reversed.

Discussion

The low and nonsignificant correlation between s/m and movement time scores is in agreement with the results of other studies from this laboratory (1, 3, 4, 8), confirming the inference that there is neuromotor specificity as between static strength and strength in action. We have found no published investigation of the possible influence of weight training on reaction time, although some enthusiasts have informally expressed their conviction that this currently popular form of training does quicken response. The factual evidence obtained in the present study indicated that it does not improve reaction time, but it does improve the speed of a simple basic arm movement. Previous studies have yielded conflicting evidence on this point.

For example, Wilkin (9) in 1952 measured arm speed, using the rate of turning a large two-handed crank placed vertically in front of the subject.

His experimental group, when subjected to a semester of weight training, showed no significant difference from a control group. Masley, Hairabedian, and Donaldson (7) in 1953 measured arm speed as the rate of turning a one-handed frontal plane crank. They found no significant difference in the improvement of a weight training group as compared with an inactive control group. Surprisingly, they did find that the weight training group improved significantly more than a volleyball playing group. The results are therefore equivocal.

In the experiment by Masley and others, arm strength was estimated by the McCloy method, which may be considered to yield a measure of endurance rather than strength, since the scoring is on the basis of number of chin-ups or dips that can be done by the subject. Significant gains in this type of strength, as well as in crank-turning speed, were found in the weight training group. The volleyball group gained in strength, but not in speed. Correlations between raw scores in speed and strength were nonsignificant.

Lotter (5) has recently found that the correlation is approximately zero between the maximal speed of crank turning and speed in a single non-repetitive arm movement of similar direction. For this reason, results might be quite different using one of the kinds of movement, as compared with the other. It would seem that the speed of a single discrete arm movement as tested in the present experiment would logically be most directly related to the measured strength/mass ratio or changes in it resulting from training exercise or other factors. We have indeed found evidence that there is a correlation between changes in s/m and changes in speed of movement. While the correlation is statistically significant, it is definitely not large.

Possibly it would have been larger if a greater change in s/m had been produced. However, it must be kept in mind that the observed 22 percent mean experimental group change in s/m is a substantial increment. The variability in amount as between individuals is ample to cause a correlation; the interval $\pm 1\ \sigma$ corresponds to changes of zero to 44 percent in s/m. This is 72 percent as large as the difference between individuals in initial s/m scores; the relative variability of MT changes is even larger than this. It therefore seems unlikely that the low correlation is a result of restricted range of individual differences. It seems more reasonable to believe that the amount of intrinsic relationship is simply not very large.

The problem of experimental design in a study such as the present one raises certain issues. To determine if an influence causes a change, the armchair experimentalist prefers a rigid two-group design: $A_x - B_x$, $A_c - B_c$, where A and B refer to test and retest, with the subscripts denoting experimental and control groups. The amount of the experimental effect can be computed as the difference $B_x - B_c$ when $A_x = A_c$; it is also computed as the difference $(A_x - B_x) - (A_c - B_c)$ with the requirement that A_x and A_c be nearly equal. Unfortunately, the harsh realities of actual research are frequently incompatible with this idealized design. Moreover, this particular design is not essential. The real interest is, in fact, directed to the population of differences $A_x - B_x$. Use of a control group may simply be needed to

insure that a difference was not caused for example by a practice effect, in which case demonstration that $A_c - B_c$ is not positive may be all that is needed. There is of course the necessary assumption that the difference $A_c - B_c$ is sensitive to practice or whatever influence is being controlled, without occlusion by other influences.

Note that meeting the condition $A_x = A_c$ obviously offers no assurance of equal vulnerability to disturbing influences or equal potentiality for change on the part of both $A_x - B_x$ and $A_c - B_c$, except when the correlation between A_x and $(A_x - B_x)$ is high and the correlation between A_c and $(A_c - B_c)$ is also high. This assumption is necessary (although implicit) in the rigid design first described, a point that is seemingly ignored by those who insist that this design or a matched pair design is necessary and adequate. In general, the difference $A_c - B_c$ approaches zero and cannot show any correlation with A_c.

The virtue of $A_x = A_c$ thus rests implicitly on the assumption that there is a high correlation between an equating variable (initial score) and the variable that it is desired to control (potentiality for change). If the equating, whether natural or artificial, does not involve a high correlation, nothing has been gained except a false feeling of security. If the correlation approximates zero, one has evidence that the equating scheme, regardless of how elaborate, yielded neither a statistical nor an experimental advantage (6).

In the present study, the correlations between initial score and amount of change turn out to be low and nonsignificant. The observed coefficients in the experimental group are —.03 for s/m, .31 for MT and .26 for RT. In the combined group of 62 subjects they are —.06, .24, and .23. Nothing would be gained by equating for initial s/m scores. Note that while the two groups are equal in initial MT, this is of no consequence. It is the correlation that determines the situation, and it is too low to be useful. Reduction in error variance takes the form $\sigma^2 - \sigma^2 r^2$ (6), and r^2 for both MT and RT is less than .06.

Randomization of subjects, rather than equating, offers the only true assurance of equal vulnerability to change. However, if this is not possible, one is not thereby justified in assuming that a control group is invulnerable to change. For this to obtain, there would have to be some aspect of the assignment procedure that would create a strong bias away from vulnerability in the control group. Logical consideration will reveal that equal vulnerability need not be assumed unless one expects to subtract control gains from experimental gains in order to quantify net gains. A distinction must be made between the rigid assumptions required for mathematical proof in developing basic statistical theory and the more flexible assumptions involved in application. In the latter case, statistical methods are not an end in themselves. Rather, they are simply a help to the experimenter in his interpretation of the facts that he observes.

In the present study it was not possible to use formal randomization. Chance-selected groups of college students cannot be forced to adjust their lives to suit the desires of the experimenter. Any such attempt would, in

itself, create motivational differences. We had to be satisfied with securing one group of subjects who were willing and desirous to undertake a semester of bodybuilding classes emphasizing certain prescribed exercises and another group of subjects who were willing and desirous to undertake a semester of avoidance of systematic exercise. As it happened, the exercised group was significantly low in initial s/m ratio (to the extent of 15 percent) as compared with the unexercised group. Possibly this reflected a need of the exercised group to enroll in a course in bodybuilding. It is not crucial to interpretation of the other facts. As shown above, there was no correlation between initial s/m scores and amounts of gain or loss.

Speed test scores are apt to be improved by practice. The gains in the exercised group evidently were not caused by practice inherent in the testing procedure, since the unexercised group did not gain. Individual amounts of gain or loss in s/m within the exercised group were found to exhibit a small but significant correlation with amounts of gain or loss in speed of movement. Combining the two groups resulted in a larger sample that was apparently distributed normally in both variables and could be thought of as representing a more comprehensive population of differences than the exercised sample. The correlation within this larger sample was slightly less than that observed in the exercised group, but possibly offers a more dependable estimate of the relationship. There is no crucial need to accept the use of a composite sample; the end result is the same if analysis is limited to the smaller groups.

The size of the correlation coefficient relating changes in s/m and speed (.39) was well above the critical value .25 required for statistical significance at the 5 percent level. Indeed, the F ratio (10.6) would have passed a significance test at the 0.5 percent level. Nevertheless, the eta coefficient (.47) was nonsignificant; it would have had to be .55 to have passed the 5 percent test. Some writers are unaware that eta is a very inefficient statistic, typically having a sampling error more than twice as large as for r.

We have given the frequency distributions of the changes in order to show that combining the groups did not cause bimodality of s/m. The apparent normality is unimportant. It is often said that normality of a bivariate distribution is required if r is to be used. Actually, it can readily be demonstrated through the use of normalizing transformations that marked skewness can in fact often be present without serious impact. Approximate linearity of regression is the important consideration. If there is a U-shaped regression the coefficient r can seriously underestimate the relationship. The variance analysis of regression was necessary in this case because the combined sample might have exhibited nonlinearity. The method deserves wider use when nonlinearity is suspected and there is a large enough number of cases. It permits the extraction and testing of both the linear (r) and the nonlinear (eta) components of the regression. It is described in most of the modern statistical texts, for example, McNemar (6).

Conclusions

1. Conditioning exercises of the progressive resistance type that do not directly involve a lateral arm test movement apparently cause increased mean arm strength in the test position and increased mean speed of the test movement.

2. In the arm movement studied, individual differences in the amount of change in the strength/mass ratio have a low but significant correlation with individual changes in maximal speed of movement.

3. When no changes are involved, there is no consistent correlation between individual differences in strength/mass ratio and maximal speed of arm movement. This supports the theory of high neuromotor specificity.

4. The conditioning exercises used in the experiment have no influence on reaction time ability.

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Social Status and Mental Health of Boys as Related to Their Maturity, Structural, and Strength Characteristics[1]

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Abstract

The purpose of this study was to determine the relationship between criteria of personal and social adjustment and the maturity, structural, and strength characteristics of boys 9 through 14 years of age. The personal and social adjustment criteria were derived from a sociometric questionnaire and an inventory-type instrument, the Mental Health Analysis. The experimental variables consisted of skeletal age, various anthropometric tests, and selected strength test formulae and batteries. When the sociometric questionnaire was used, positive relationships between peer status and body size and muscular strength were found. However, when the inventory-type instrument was used, the results were conflicting and contrary to those with the sociometric questionnaire.

THE DEVELOPMENT OF personality and the achievement of desirable social adjustment have been objectives of physical education since early leaders led our profession away from the formalized type of program that emphasized gymnastics, calisthenics, and marching. Research in the area of personal and social adjustment has been largely neglected by investigations in physical education; most experiments undertaken by psychologists and sociologists have related physical attributes to leadership qualities, the establishment of friendships, and social behavior. Therefore, a study was undertaken to determine the relationship between criteria of personal and social adjustment and the maturity, structural, and strength characteristics of boys 9 through 14 years of age.

Related Studies

In relating body build to social traits and play activities of high school boys, Bartell (1) concluded that there was a tendency for boys with medium builds to be better adjusted socially than either obese or slender subjects. Hanly (9) studied somatotype ratings and reputation traits of junior high school boys and found that the traits good-at-games and active-in-games correlated .48 and .45 respectively with mesomorphy, both being significant at the .01 level. Jones and Bayley (12) studied the physical maturity

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[1]This study was conducted with data from the Medford, Oregon Boy's Growth Study. Subsidization of the Growth Study was provided by Medford Public Schools, Southern Oregon College, Athletic Institute (Chicago, Ill.), Oregon State Education Department, and the Office of Scientific and Scholarly Research of the University of Oregon. Acknowledgements for testing assistance are made to University of Oregon graduate and Southern Oregon undergraduate students.

of adolescents as related to behavior, and found that early-maturing boys were more likely to get and maintain prestige associated with athletics.

In terms of the physical and motor ability of children, Jones (11) observed that boys superior in strength at the end of adolescence showed a tendency to be tall, heavy, mesomorphic, early-maturing, proficient in athletics, high in popularity and social prestige, and well-adjusted. Bookwalter (3), however, concluded that the stability of elementary school children appeared to have little relationship to performance in physical activities requiring skill. Rarick and McKee (16), on the other hand, utilizing the case study technique, found that children of superior motor performance tended to be active, popular, calm, resourceful, attentive, and cooperative, as compared with the children of inferior motor performance. The latter group frequently showed negative personality traits and were described as being more often shy, retiring, and tense. Also, in a study by Popp (15), five judges generally recognized in high school boys with high Physical Fitness Index scores the many varied traits they would like to see in sons of their own. In this connection, Jones (10) reported that boys high in physical strength tended to have good physiques, to be physically fit, and to enjoy a favored social status in adolescence.

Fulton and Prange (7) studied the traumatic effect of rejection or lack of status on personality and found that boys who were not chosen by their teammates did not differ significantly from those boys who were most frequently chosen. Kuhlen and Lee (13), on the other hand, found that to be active in games was particularly important for the social acceptability of boys, especially during the adolescent years. The results of a similar experiment by Tryon (20) were in essential agreement with Kuhlen and Lee. She concluded that the 7th grade boy who lacked skill and had a distaste for games was ridiculed and shunned by the group, at the 12th grade, outstanding athletic skill maintained the prestige of a boy even though he had few other assets.

In a study of athletic skills, Biddulph (2) found that high school students ranking high in athletic achievement demonstrated a significantly higher degree of personal and social adjustment than did students ranking low in this trait. McCraw and Tolbert (14) also found a substantial relationship between the choice of "best athlete" and athletic participation and between the choice of "best liked" and athletic participation. In an evaluation of the effect of competitive athletics upon young boys, Fait (6), Seymour (17), and Skubic (18) could find no conclusive evidence suggesting that these activities were harmful; rather, the latter two studies supported previous research by concluding that the athletic participant was accorded significantly more social acceptance than the nonparticipant.

In the above studies, various peer status evaluations and teacher judgments were utilized as criteria of social adjustment. In general, the results showed a relationship between these criteria and physique type, body size, muscular strength, motor performance, and athletic ability. Comparable studies using personality inventory-type tests as criteria were not reported.

Procedures

PERSONAL AND SOCIAL ADJUSTMENT CRITERIA

Two criteria of personal and social adjustment were utilized in this study. One of these, a sociometric questionnaire, was administered to the boys 9 through 11 years of age; the second of these, the Mental Health Analysis, was given to the boys 12 through 14 years of age.

Sociometric Technique. The sociometric questionnaire asked each boy to list as many other boys in his home-room who were his friends and with whom he would like to go to the movies, play sports, study homework, and invite to a birthday party. The questionnaire was administered to all boys in every home-room containing subjects included in this study for the ages of 9 to 11 years inclusive.

Mental Health Analysis (19). The Mental Health Analysis has two sections, with five categories in each, and a total score. Section I is designed to measure mental health liabilities and includes categories pertaining to behavioral immaturity, emotional instability, feelings of inadequacy, physical defects, and nervous manifestations. Section II measures mental health assets and covers the categories of close personal relationships, interpersonal skills, social participation, satisfying work and recreation, and adequate outlook and goals.

EXPERIMENTAL VARIABLES

The experimental variables in this study, 14 in all, consisted of one maturity, eight structural, and five strength tests. The anthropometric tests were selected to evaluate aspects of the subjects' body bulk, linear dimension, girth structure, and nutritional status. The strength tests were related to the development and endurance of the arm and shoulder girdle musculature, the gross strength of the body, and relative strength as related to each boy's age and weight. Following is a list of these variables:

Maturity measures: Skeletal age, as assessed from wrist-hand X-rays by application to the Greulich-Pyle standards (8).

Structural measures: body weight, standing height, upper arm girth, chest girth, hip width, calf girth, lung capacity, and Wetzel Physique Channel.[2]

Strength measures: Roger's arm strength score, McCloy's arm strength score, Strength Index, Physical Fitness Index (5) and average for 12 cable-tension strength tests (4).

SUBJECTS

The subjects included in this study were 199 randomly selected boys. The numbers at the various chronological ages were as follows:

Age 9 years	40	Age 12 years	28
Age 10 years	32	Age 13 years	32
Age 11 years	33	Age 14 years	34

Each boy was tested within two months of his birthday. This restriction on age was imposed so as to secure reasonable homogeneity among the subjects as related to chronological age.

Analysis of Data

The upper seven and the lower seven scores for each age group were selected separately for each situation analyzed, as follows:

1. Ages 9 through 11 years: for two tabulations made from the sociometric questionnaire, number of times each boy was chosen by others and number of boys he chose on the questionnaire.

2. Ages 12 through 14 ears: for the two sections, the five categories within each section, and the total score on the Mental Health Analysis.

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[2] For purpose of statistical analysis, the Wetzel Physique Channels were arbitrarily assigned numerical values as follows: B-4, 1; B-3, 2; B-2, 3; B-1, 4; M, 5; A-1, 6; A-2, 7; A-3, 8; A-4 9.

TABLE 1.—SUMMARY OF t-RATIOS OF EXPERIMENTAL VARIABLES FOR BOYS 9 THROUGH 14 YEARS OF AGE DIVIDED ON THE BASIS OF HIGH AND LOW SCORES ON SOCIAL STATUS AND MENTAL HEALTH CRITERIA[a]

	Social Status		Mental Health Analysis												
	TC	NC	I	I-A	I-B	I-C	I-D	I-E	II	II-A	II-B	II-C	II-D	II-E	TS
1. Skeletal Age	1.36	—.45	1.09	.73	.10	.41	.13	.68	.76	.53	.36	1.78	.79	.40	.89
2. Body Weight	.81	—.38	.41	.22	—.50	—.62	—.75	—.12	—.91	.14	—.49	.65	.23	—.06	.33
3. Standing Height	1.86	.17	.64	—.06	—.62	.03	—1.10	.43	—.40	.35	—.02	1.43	—.17	—.33	.10
4. Upper Arm Girth	.75	—.55	.07	.07	—.14	—.51	—.43	.63	—.84	.14	—1.20	.28	—.28	.24	.01
5. Chest Girth	.93	.03	.26	.57	—.37	—.96	—.52	—.52	—.82	.20	—.56	.30	.28	—.03	—.28
6. Hip Width	1.69	.55	—.39	.18	—.63	—.14	—.97	.19	—.78	—.03	—.38	.36	.52	—.62	—.83
7. Calf Girth	—3.59	—.74	1.08	.30	.15	.06	.01	—.39	—1.23	—.02	—.10	.17	.41	—.04	.13
8. Lung Capacity	1.29	.78	.52	—.02	.15	.02	—.35	—.14	—.91	—.62	—.73	.62	.03	—.10	.14
9. Wetzel Physique Channel	—.76	—.67	.07	.58	—.16	—1.05	.16	—1.15	—1.60	—.22	—1.14	—1.09	.84	.56	—.77
10. Rogers' Arm Strength	2.34	.62	—.46	—.63	—.54	.04	—.53	.50	.06	—.16	—.39	.59	—.76	1.03	.38
11. McCloy's Arm Strength	2.67	.03	.16	—.39	—.52	—.36	—.72	.02	—.43	.07	—.17	.79	—.16	.63	.13
12. Rogers' Strength Index	1.70	.27	—.30	—.76	—.40	—.66	—.68	.45	—1.75	—.63	—1.24	—.39	—1.11	.29	—.44
13. Rogers' Physical Fitness Index	1.23	.52	—.83	—1.58	.03	—.04	.19	1.29	—1.80	—1.10	—1.02	—1.27	—2.89	.07	—.28
14. Cable-Tension Strength Test Average	1.71	.67	—.51	—1.45	—.34	.14	—1.25	.01	—1.58	—.58	—.84	—.12	—1.17	—1.34	—.87

[a] For 40 degrees of freedom, t ratios of 1.68, 2.02, and 2.71 denote significance at the .10, .05, and .01 levels, respectively. Minus signs preceding t ratios indicate instances where boys with lowest scores on sociometric or mental health tests had the highest means on the experimental variables.

Code:

Social Status (Sociometric Questionnaire)
1. TC: Times Chosen
2. NC: Number Chosen

Mental Health Analysis
1. I: Liabilities Section Score
2. I-A: Behavioral Immaturity
3. I-B: Emotional Instability
4. I-C: Feelings of Inadequacy
5. I-D: Physical Defects
6. I-E: Nervous Manifestations
7. II: Assets Section Score
8. II-A: Close Personal Relationships
9. II-B: Inter-Personal Skills
10. II-C: Social Participation
11. II-D: Satisfying Work and Recreation
12. II-E: Adequate Outlook and Goals
13. TS: Total Score

Thus, a total of 15 different classifications were made. For each classification, there were 21 boys with high scores and 21 boys with low scores, as the boys in the three ages (9 to 11 years and 12 to 14 years) were combined.

For each of the 15 classifications, the means for the boys with high scores and the boys with low scores were computed for each of the 14 experimental variables. In each instance, the difference between the means was tested for significance. The standard error of the difference between means for uncorrelated groups was calculated; a t ratio was then determined. This is known herein as the original method of analysis.

In order to examine the adequacy of the original analysis procedure, an additional process was performed. This process, known herein as the alternate method, consisted of reversing the method of forming the contrasting groups. Instead of selecting the highest seven and the lowest seven boys at each age on the basis of their scores on the sociometric or mental health tests, a similar division was made on the basis of their scores on each of the experimental variables. This divisional process was performed on all 14 experimental variables for the boys 9 through 11 years of age. For the boys 12 through 14 years of age, the groups were formed for the following six variables only: skeletal age, calf girth, Wetzel physique channel, Rogers' Strength Index and Physical Fitness Index, and the cable-tension strength test average. Furthermore, the alternate analysis was made only on the liabilities section score, the assets section score, and the total score on the test.

Results

BOYS 9 THROUGH 11 YEARS OF AGE

A summary of the differences between means on the experimental variables for the subjects scoring highest and lowest on the sociometric questionnaire, expressed as t ratios, appears in Table 1; similar results by the alternate method are presented in Table 2. Observations relative to these results follow:

Number of Times Chosen.

1. In the original analysis, the calf girth mean for the boys chosen least frequently was greater than for those chosen most frequently; the difference between the means was significant above the .01 level of confidence, since the t was 3.59. By the alternate method of analysis, however, the difference between the means was not significant (t = .61).

2. By both the original and alternate methods of analysis, the differences between the means for the following variables, given with t ratios, were significant from the .10 to the .01 levels and were in fairly close agreement: McCloy's arm strength score (2.67 and 2.75), Rogers' arm strength score (2.34 and 2.19), and standing height (1.74 and 1.71). In all instances the higher means were achieved by the boys chosen most frequently on the sociometric questionnaire.

3. In addition to calf girth discussed above, inconsistencies were found between the two methods of analysis for four experimental variables. As a

TABLE 2.—SUMMARY OF t VALUES FOR TIMES BOYS 9 THROUGH 11 YEARS OF AGE WERE CHOSEN AND NUMBER OF BOYS CHOSEN ON THE SOCIOMETRIC QUESTIONNAIRE DIVIDED ON THE BASIS OF HIGH AND LOW SCORES ON EXPERIMENTAL VARIABLES

	Times Chosen	Number Chosen
1. Skeletal Age	.54	.43
2. Body Weight	2.35	.25
3. Standing Height	1.71	.00
4. Upper Arm Girth	.41	1.14
5. Chest Girth	.96	.33
6. Hip Width	1.13	1.29
7. Calf Girth	.61	.86
8. Lung Capacity	.64	1.00
9. Wetzel Physique Channel	.17	1.00
10. Rogers' Arm Strength	2.19	.38
11. McCloy's Arm Strength	2.75	.63
12. Rogers' Strength Index	1.04	.56
13. Rogers' Physical Fitness Index	.52	.13
14. Cable-Tension Strength Test Average	.39	1.00

result of the original analysis, significant at the .10 level, the boys chosen most frequently had the highest means on the cable-tension strength test average (1.71), Rogers' Strength Index (1.70), and hip width (1.69); the differences for these variables were not significant by the alternate method. By the alternate method of analysis, significant between the .05 and .01 levels, the boys chosen most frequently had a higher mean body weight (2.35) than did those chosen least frequently; the difference for this variable was not significant by the original method of analysis.

4. The differences between the means for the following experimental tests were not significant by either method of analysis: skeletal age, upper arm girth, chest girth, lung capacity, Wetzel physique channel, and Rogers' Physical Fitness Index.

Number of Boys Chosen. By the original method of analysis, the differences between the means on the 14 experimental tests for the boys who chose many and those who chose few boys from their home-rooms were not significant; no t ratio exceeded .78 in magnitude. The t's for the alternate method (Table 2) were generally higher, although again not significant. The highest t was 1.29 for hip width, in which instance boys who chose the greatest number of classmates also had the higher score.

BOYS 12 THROUGH 14 YEARS OF AGE

For the original analysis, the summary of t ratios for the difference between the means on the experimental variables for the subjects scoring highest and lowest on the Mental Health Analysis appears in Table 1. The results by the alternate method of analysis are presented in Table 3.

In considering the findings from both the original and alternate analyses, only one difference between means was significant at the .01 level for all

comparisons made, including the ten categories, the two sections, and the total score on the Mental Health Analysis. By the original analysis, the subjects indicating the fewest assets in the Satisfying Work and Recreation category had a higher Physical Fitness Index mean than did those with highest scores in this category. The t ratio for this difference was 2.89 by the original method of analysis; by the alternate analysis, the t ratio was 1.73, still favoring the boys with the least stated assets, but significant only at the .10 level. Three differences between the means did reach significance at the .10 level by the original method of analysis, but were not verified by the alternate method. The subjects with fewest Assets Section scores had higher means on the Strength Index and Physical Fitness Index than did those with greatest assets scores; the t ratios were 1.75 and 1.80 respectively. The subjects with highest scores in the Social Participation category had higher mean skeletal ages than did those with lowest scores in this section of the Mental Health Analysis; this t ratio was 1.78.

TABLE 3.—SUMMARY OF t VALUES OF LIABILITIES, ASSETS, AND TOTAL SCORES ON MENTAL HEALTH ANALYSIS FOR BOYS 12 THROUGH 14 YEARS OF AGE DIVIDED ON THE BASIS OF HIGH AND LOW SCORES ON EXPERIMENTAL VARIABLES

	Liabilities	Assets	Total Score
1. Skeletal Age	1.25	.57	1.17
2. Calf Girth	–.47	–.54	.01
3. Wetzel Physique Channel	.38	–.33	.16
4. Rogers' Strength Index	.26	–.51	–.06
5. Rogers' Physical Fitness Index	–.36	–1.73	–1.46
6. Cable-Tension Strength Test Average	–1.37	–1.32	–1.66

Conclusions

BOYS 9 THROUGH 11 YEARS OF AGE

1. The boys chosen most frequently on the questionnaire have higher arm strength than those chosen least frequently, as indicated by both McCloy's and Rogers' formulae. When McCloy's arm strength score was used, the significance was at the .01 level; for Rogers' arm strength score, the significance was between the .05 and .01 levels.

2. Trends were found for certain experimental variables, in that significance between the means resulted from the use of either the original method of analysis or from the alternate method, but not from both methods. These were: body weight, calf girth, hip width, Rogers' Strength Index, and cable-tension strength test average. In all instances but calf girth, the higher means were achieved by the boys chosen most frequently on the questionnaire.

3. Based on the number of boys each subject chose on the sociometric questionnaire, no significant difference was obtained between the means on the experimental variables.

BOYS 12 THROUGH 14 YEARS OF AGE

Only one difference between means on the Mental Health Analysis for the boys 12 through 14 years of age was significant at the .01 level; by the original analysis, the subjects indicating the fewest assets in the Satisfying Work and Recreation category had the higher Physical Fitness Index mean. Again by the original method of analysis, three differences were significant at the .10 level. However, with a matrix of 182 comparisons between the 13 scores on the Mental Health Analysis and the 14 maturity, structural, and strength tests, the one difference between means significant at the .01 level and the three differences between means significant at the .10 level could logically occur by chance alone.

Discussion

In this study it was observed that, when the sociometric questionnaire was used, positive relationships between peer status and body size and muscular strength were found. However, when the inventory-type instrument (Mental Health Analysis) was used, the results were conflicting and frequently contrary to those with the sociometric questionnaire.

It is recognized, of course, that somewhat different factors were tested by these two approaches. Nevertheless, thought may well be given to the reasons for such differences. While inconclusive, a study by Popp (15) may provide a lead for the exploration of this problem. In his investigation, case studies were conducted for 20 sophomore high school boys with high Physical Fitness Indexes and a similar number with low indexes. Both the Washburne Social Adjustment Inventory and the Mooney Problem Check List were administered to both groups. The differences between the means on the Washburne test were not significant and the boys with low Physical Fitness Indexes checked fewer problems on the check list than did those with high indexes.

Yet, when these 40 boys were arranged alphabetically on a single list, to obscure their Physical Fitness Index scores, five administrators and teachers in their school independently designated 69 percent of the group with the high indexes as "boys they would most like to have for sons." This same trend was present and enhanced, when these judges indicated 75 percent of the boys with low indexes as "boys they would least like to have for sons."

Thus, it would appear that boys with superior physical traits enjoy greater peer status and are more favorably judged as having desirable over-all personality traits by administrators and teachers than are boys with inferior physical traits. Yet, when they answer questionnaires about themselves, the situation becomes somewhat reversed. The physically superior boys either recognize more problems and inadequacies within themselves or are more critical of their shortcomings in this respect.

As a consequence of these observations, it is suggested that investigations be directed toward determining the source of the differences between the results obtained through the inventory-type of personal-social testing and those methods involving sociometric techniques and judgment ratings. From such investigations, too, might come the construction of improved instru-

ments for personal-social adjustment evaluation. Or, the profession might well gain better insight into the shortcomings of these evaluative methods and how their use may be improved.

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Sports and Recreational Practices of Union and Confederate Soldiers[1]

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Abstract

This study investigated the sports and recreational practices of Union and Confederate soldiers during the Civil War. The four specific purposes of the study were: (1) to investigate the place of sports and recreation in the life of Union and Confederate soldiers during the Civil War; (2) to discover what types of sports and recreational activities were engaged in by the soldiers of the North and South; (3) to find what extent the various activities were participated in by Union and Confederate soldiers; (4) to discover what activities were the most popular with the Union and Confederate troops and the causes[2] for their popularity. The library and documentary research technique was used to gather the data. Sports and recreational practices discovered were classified under one of five major headings: combatives, country sports, quiet games, athletic games and contests, and miscellaneous sports and recreational activities.

THIS STUDY IS BASED on the premise that the common sports and recreational practices of the American Civil War soldier were similar to such practices in the various geographical areas from which the soldier came. It is therefore significant to study such activity so that more insight may be gained regarding the sporting culture of the mid-nineteenth century in America.

There appears to have been no study conducted specifically on the sports and recreational practices of Union and Confederate soldiers during the Civil War. Wiley (44, 45) and Commager (40) have devoted some space to the leisure time activities of the soldiers of both North and South. Fink (39) conducted a study on the recreational pursuits of the Old South but limited her study to the years prior to 1861.

Operational Definitions and Methods

For the purpose of this study the term "sport" is applied to any play, pasttime, game, or contest involving a reasonable degree of individual skill and physical prowess (41).

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1 This study was made under the direction of Dr. Marvin H. Eyler, University of Maryland, College Park, Maryland.

2 The use of this word taken from *Understanding History* by Louis Gottschalk (42). "The term 'cause' as used by historians, must . . . be regarded as a convenient figure of speech, describing motives, influences, forces, and other antecedent interrelations not fully understood." Causes are not subject to observation and therefore must be reasoned from evidence.

The term "recreational practice" was more difficult to define. A recreational practice can be broadly defined as an activity engaged in voluntarily for enjoyment and relaxation of the participant, but this definition was too all inclusive for the purpose of this study. The term was arbitrarily limited to activities which included two or more individuals. This eliminated such individual recreational pursuits as reading and letter writing.

S. C. Staley's (43) classifications of athletic games, combative contests, and country sports were arbitrarily chosen. A fourth classification was a quiet game, one in which there is no great amount of gross body movement and which is normally considered a game of chance and/or a game involving some skill and concentrated mental activity. All those activities which did not fall into one of these four categories were classified as miscellaneous.

The library and documentary research technique was used to gather the data. The study is based on primary sources. Manuscripts, published letters, diaries, journals, memoirs and reminiscences, and regimental histories of the participants presented a picture of the sports and recreational practices of the Civil War soldier.

Sports and Recreational Practices

Judge Oliver Wendell Holmes once said that war was an organized bore. The Civil War was not all fighting, and the fighting was not all the pitched battles that have been commemorated in history. As indicated by such credible military historians of the Civil War as Bruce Catton and Bell Wiley soldiering during the Civil War was a rather dull job and comparatively little time was occupied in actual fighting. The soldier's greatest enemy was always simple boredom. Most commanders tried to keep their men busy at the job of being a soldier. Even with their duties the soldiers were left time in which they were forced to devise some type of recreation for their own entertainment. Both the men in blue and their gray-clad opponents displayed considerable ingenuity in meeting the problem.

The sports and recreational practices discussed in this study helped to a great extent to keep the men and officers contented with their lot as soldiers by occupying the time when they might otherwise have been thinking about their hardships. It gave them a wholesome outlet to fill many of their long tedious hours as they resumed day after day the monotonous job of being a soldier. The diversions engaged in by the Civil War soldier were numerous and varied; apparently a considerable number of men found a good deal of pleasure in soldiering.

COMBATIVE CONTESTS

Boxing was a favorite form of diversion for the soldiers and was such a common occurrence among some regiments that an Ohio volunteer mentioned that it helped to make up a normal day's activity in the camp of the 3rd Ohio (11).

To engage in such a sport as boxing seems to have been a mark of manliness. One soldier in a letter home to his mother told of accidently bumping a fellow soldier in the ranks (9). This aroused the other man's temper, and

he challenged the letter writer to a fight. The soldier declined and wrote, "I suppose he thought as others did, that because I never wrestle, or scuffle or box, like some of the others that I haven't much spunk."

Boxing also afforded spectator recreation to many of the soldiers. A soldier in the 5th New York Volunteers mentioned that the members of his regiment witnessed amateur prize fights in their camp (26).

Many of the bare-knuckle matches were fought under some form of rules, and the participants were expected to obey these rules. One Union colonel, who was acting as referee, put a soldier in the guard house for attempting to take unfair advantage of his opponent (26).

The sport of boxing seems to have been engaged in by the soldiers principally for two reasons, plain enjoyment or exercise and to settle some quarrel or grudge that arose between two soldiers. A soldier of the 27th Indiana suggested the following: "Occasionally there was a down right fist fight, the result of some quarrel. . .In fact, it was not safe to quarrel unless one wanted to fight (24).

The sport of staging fights between gamecocks, usually armed with spurs, had enjoyed great popularity among American sportsmen since early colonial days. Cock fighting was a popular form of amusement among Americans of all sections of the country by the mid-nineteenth century. The soldiers of both the North and South brought their love for this pastime with them. When two roosters could be found they were prepared and a fight staged. A Southern soldier complained that the idleness of the Sabbath was a great evil, as there was nothing to read, and cock fighting was a chief amusement of the men (21).

The saber was still a somewhat useful weapon during the Civil War. It was carried by most mounted troops of both sides. Many officers carried a saber on their belts as a sidearm or for show. Availability of the weapon led to many fencing matches among the men in the camps of the North and South.

Fencing enjoyed its greatest popularity among the officers and cavalry troops. This was quite natural in light of the fact that the common foot soldier did not carry a saber as standard equipment. Fencing was also considered quite proper for an officer, while other more vigorous sports were not deemed dignified enough. One young officer of the 57th New York Volunteers remarked in his diary that fencing was one of the most popular activities enjoyed by the officers of his regiment and was engaged in by all for an hour or so every afternoon (7).

Free-for-alls were common in the camps of both armies. A member of a Virginia infantry regiment described one as follows: "The quietude of camp was sometimes broken by a free-for-all between our two Irish companies. The Irishmen never used deadly weapons, but fought in their own loved manner with sticks and fists" (18).

Wrestling was a popular activity within the encampments of both armies. An officer of a Wisconsin regiment commented that wrestling contests were held frequently by the men under his command (19). A soldier with the 4th South Carolina Volunteers wrote home to his family that as he looked about him he counted 48 men engaged in wrestling matches (35).

COUNTRY SPORTS

Boating had its followers among the soldier sportsmen of the Civil War. A young officer of the 57th New York Volunteer Infantry commented in his diary that going rowing in an old boat, while stationed at the Washington Naval Yard, gave him a great deal of pleasure (7). Boat races were sometimes held. A private of the 7th Connecticut mentioned in his regimental history that such a boat race was held for prizes on Thanksgiving Day of 1863 (38).

Since most of the bivouacs were placed near a supply of water whenever possible, fishing emerged as an enjoyable and frequent pastime of the soldiers. A member of a Texas Ranger outfit noted in his journal that fishing was a regular activity for the Rangers from the months of May to September 1961. He wrote in September 1861, "The Los Morass is full of the finest fish; principally trout, and my everyday employment is hauling them from their liquid homes" (8). The diary of a soldier in Company B, 18th Regiment Indiana Volunteers mentioned that while they were camped near a nice creek the boys fished continually (3).

These soldier fishermen resorted to various techniques of catching fish. One Union soldier reported good luck in the use of a trolling hook and line from a boat (25). Members of the 51st Pennsylvania made good use of shad and herring nets which abounded near where they camped (34), whereas a Confederate soldier from Alabama noted that the best quality of fish caught by his comrades was brought in by the hook and line sportsmen (36).

The sporting urge of fishing was frequently secondary to that of hunger. Fishing supplemented the soldiers' rather meager diets. A Texas boy noted in his diary the following entry: "The fish were not very large specimens, but fine for the frying pan (8)."

Horseback riding was a favorite recreational activity of mid-nineteenth century America when the horse was a main means of transportation. Most all officers and cavalry troops had access to horses and riding was engaged in by these men for recreation. Most of the riding for pleasure was done by those men who had been camped at one location for an extended period of time. During active campaigns the men were usually more than happy to have the opportunity to dismount and rest for awhile. General Babcock wrote in his diary that "the officers often went off for horseback rides down the island, singly or in groups (5)."

Hunting, like fishing, was many times prompted by a double motive. Soldiers hunted game both for the sporting pleasure derived from the desire to pursue and kill prey and for the more practical purpose of filling their empty larders.

A rebel soldier with W. P. Lane's Rangers noted in his diary on several occasions what fine sport the men had hunting (8). E. E. Johnson's diary revealed the other motive, when he wrote: "Being without provisions and not wishing to starve, I and a friend got our guns and started out to see what we could get" (3).

The soldiers of the North and South turned to varied and assorted weapons in hunting the game close to their campsites. The most usual weapon was the gun, but now and then the soldiers used more ingenious methods of killing or capturing game. Members of the 59th Illinois, armed only with torches and sticks, flushed out and killed hundreds of birds (45). Some of the soldiers were more fortunate in the hunting aids they had at their disposal. A soldier of the 6th Army Corps commented that his comrades used dogs and double-barreled shotguns in tracking down and killing wildlife which abounded near where they camped (30). The soldier hunters of the Civil War gave most of their attention to small game, such as rabbits, wild turkeys, squirrels, possums, coons, and quail, and less frequently hunted large game, such as deer and wild hogs.

The winter sports of ice skating and sled riding, although engaged in by some of the soldiers, were not widely popular activities. On cold, clear days a few of the 146th New Yorkers would go ice skating on Potomac Creek (23).

Swimming was popular with the soldiers of both armies, principally for two reasons. The first was recreational in that it was a chance to relax and have fun while escaping the oppressive heat of the summer campaigns. The second was an opportunity, not often afforded the soldier, to wash off the dirt and grime of a long day's march or of a recently fought battle.

A Union officer told in his diary of watching 10,000 men splashing and swimming in the York River in May of 1862, as McClellen's army was beginning its snail like approach up the peninsula toward Richmond (7). A Confederate boy wrote in his diary in June 1861 that he had observed "down by the river a merry crowd of 75 men, splashing, dashing, diving, and swimming like so many puddle ducks in a barnyard stock pond (8)."

Swimming was occasionally looked on with disfavor by officers whose responsibility it was to keep the men in good physical condition to fight. The following notation from the regimental history of the 48th Pennsylvania Volunteers serves as evidence that restrictions were sometimes placed on the swimming activity of the troops:

> The hot weather of June was calculated to bring sickness, and care had to be taken in guarding the health of the men. Too frequent swimming in the Trent was deemed imprudent, and Colonel Sigfried issued "Order No. 8" forbidding "all swimming except on Wednesdays and Saturdays," and "no soldier was allowed to swim between the hours of 9:00 a.m., and 4:00 p.m., or remain in the water longer than 10 minutes at a time (22)."

Swimming was not without its perils. The diary of a private stationed in Louisiana disclosed that two men of the 8th Indiana were eaten by alligators while swimming (10). Officers, as well as the common soldier, enjoyed swimming. An officer of the 57th New York noted in his diary that the officers of his regiment would make up a party and go swimming in the evening after the day's duties had been carried out (7).

A popular activity among the soldiers, where the ammunition supply allowed, was target shooting. Target shooting was encouraged and partic-

ipated in by the officers, as well as the noncommissioned soldier, since it related directly to the business of war. Almost all target shooting was conducted on a competitive basis. The members of the 146th New York aroused friendly rivalry by having the competition between companies (23). In the 22nd Massachusetts, target shooting was one of the regular duties of the camp, and brass and silver trophies were given to the best shots (33).

Quiet Games

Probably the most popular and most widely engaged in of all recreational activities during the Civil War was card playing. The playing of cards meant a great deal to the soldiers of the Civil War as it has to many soldiers in succeeding wars fought by this country. A Massachusetts soldier told the story of a comrade who had three fingers shot off at Shiloh. "Just my luck," he exclaimed. "I shall never be able to hold a full hand again" (6).

Card playing helped the soldier while away many an hour that might have otherwise been tedious and dull. In the tents during the evening, or anytime behind a breastwork, on a stump, log, or even the ground, the soldiers of both sides found time to enjoy a game of cards. An officer of the 33rd United States Colored Infantry noted in the regimental history that in the evening after supper the Negro troops would gather by the firesides to play cards (29). A Confederate soldier recalled passing the winter of 1861 playing cards with his fellow soldiers in the log cabins they had built for winter quarters (4).

Poker appears to have been the favorite game among the card playing soldiers of both sides; it was followed closely by cribbage, euchre, seven-up, chuck-a-luck, keno, and faro. One Northern soldier mentioned poker playing by the men of the 1st Massachusetts Infantry some 40 times in his diary (6). A Virginia foot soldier recalled in his memoirs that five out of six men played cards and that draw poker was the favorite (18).

There seems to have been a considerable amount of gambling among those who played cards. A commander of a Wisconsin regiment remembered witnessing games where a private soldier won as much as $1000 at a sitting of poker (19). One soldier felt that the characteristics of a successful gambler and a good soldier were the same. He noted in his memoirs that "it is well known that the bravest soldiers were the heaviest and best betters" (19).

There are some interesting incidents in the literature of the Civil War describing fraternizing between the soldiers of both armies during lulls in the fighting. Some of this fraternizing took the form of a friendly game of cards. The regimental history of the 146th New York tells of two members engaging several Rebels in a game of cards during the siege of Petersburg in 1864 (23).

Not all of the soldiers indulged in card playing. Some felt it was sinful to play cards and objected to card playing on religious grounds. A Confederate soldier complained of the evilness of playing cards in camp on the Sabbath (23).

No matter where, when, how, or under what conditions card games were played, they were important to the common soldiers of both the Union and Confederacy. The importance of cards to the soldier can be summarized in the following statement by a member of the 51st Indiana Volunteers: "It came to all of us as a positive necessity, and was as generous and edifying to the moral and mental manhood, as coffee was to the physical" (28).

The game of checkers was a popular pastime among the soldiers of both North and South. A private in Battery A, 1st Regiment Ohio Volunteer Light Artillery wrote to his family in 1862 that many of the men played checkers to pass the long evenings in camp (2).

Chess also found its adherents in the armies of both the Union and the Confederacy. A game of intellectual skill, it was not without its devotees on either side but never seemed to gain any considerable degree of popularity among the common soldier. A Yankee soldier commented that "it was only rarely that the statelier and less familiar game of chess was to be observed on the board" (13). When no chessmen were available a Massachusetts soldier whittled out a set and played with everybody who knew the game or would learn to play (6).

Dominoes was played by both Union and Confederate soldiers, but there is no evidence to show that it was played frequently by the men of either side. Dominoes seems to have been popular as a means of sedentary recreation by soldiers in Civil War prisons (32).

Athletic Games and Contests

Football, as it was played at the time of the Civil War, did not resemble our modern game. Rugby had not been introduced in the United States by 1860, and so the Civil War football resembled more closely our present game of soccer, in which the propelling of a round ball with the feet is the main activity of the player.

Association football was mentioned occasionally by the soldier correspondents of both sides. A Rebel soldier commented that the Southern boys learned to go back to their schoolboy sport of football and enjoyed it as much as in the days of their youth (18). *The New York Irish American* reported that an Irish brigade played football in their camp during May of 1862 (46).

Baseball appears to have been the most popular of all active sports engaged in by "Billy Yank" and "Johnny Reb." The soldiers turned out for baseball in large numbers when leisure and weather permitted. A captain of the 24th Alabama observed that while his men were waiting at Dalton to see what Sherman was going to do they played baseball "just like schoolboys (44)." The same could be said of many other regiments of Union and Confederate troops. The game daily occupied the attention of the men of the 13th Massachusetts during April and May of 1862 (27). In the evenings after dress parade a large number from the 51st Pennsylvania Volunteers would congregate on their drill field for a baseball game (34).

Baseball seems to have been played under a variety of rules and in a variety of ways. It might have been our modern version with the players running four bases, or it might have been two-base town ball, or any combination of the two methods of play. A Vermont soldier gave the following description of the game as it was played in his company: "The ball was soft, and a great bounder. To put the base-runner out, he had to be hit by the ball, thrown by the pitcher" (45). A soldier with the 22nd Massachusetts noted that "twelve of our enlisted men challenged an equal number from the 13th New York to a game of baseball, the Massachusetts' game" (33). Another soldier wrote in his diary that the boys in his company played ball with the 26th Pennsylvania in a "new way," but he had forgotten the rules under which they had played (6). Such statements would tend to support the theory that baseball during the Civil War had not yet become standardized throughout the country and that each locality had its own set of rules governing the conduct of the game.

The equipment used was, for the most part, makeshift. The bat might have consisted of a board, a section of some farmer's fence rail, or a slightly trimmed hickory limb. The ball might have been nothing more than a yarn-wrapped walnut (44). Scores of these Civil War ball games ran rather high in comparison to our modern standards. A member of the 13th Massachusetts reported beating the 104th New York 62 to 20 (27).

Town ball, similar to baseball and played between two bases, seemed to enjoy its greatest popularity among Confederate troops (14).

Cricket, the national game of Great Britain, was played only sparingly during the Civil War. This might be accounted for in part by the fact that the American game of baseball was becoming increasingly popular throughout the country during the 1850's and 1860's.

Tenpins, as it was called by the soldiers, is an excellent example of how the common soldier used his ingenuity to devise means for his own entertainment when formal sports equipment was lacking. A soldier of the 115th New York reported finding that at one camp a crude tenpin alley had been constructed by the men, who bowled artillery shells at pins termed "Rebels" (12).

Gymnastic type activities seem to have been particularly popular among those Northern troops which had a large number of foreign members in their ranks. A member of the 5th New York Zouaves recalled some members of his regiment giving a "ground and lofty" tumbling exhibition in March 1862 (26). A Massachusetts soldier recalled spending some pleasant days in camp enjoying gymnastics (6).

Horse racing was a popular activity. The availability of horses, both cavalry and officer's mounts, led to many an exciting horse race in the camps of both the Union and Confederate armies. Some were run just for fun, others for a purse or as a result of a challenge or bet. According to a member of the 9th Massachusetts one of the principal sources of amusement of his regiment was horse racing (31). A Confederate cavalryman recalled building a race track near Winchester, Virginia, and holding many thrilling races while encamped in winter quarters (17).

The sport of horse racing was probably more popular as a spectator sport among the soldiers than as a participating activity. This was because the majority of soldiers in both armies did not have horses. Horse racing, particularly in the South, had been a popular spectator sport in this country prior to the outbreak of hostilities and the soldiers brought to their camps the love of this pastime.

A Union soldier recalled the members of his brigade turning out in large numbers to witness horse races in camp (31). Steeplechases, as well as flat races, were popular among the soldiers. One of the most famous was the Grand Irish Steeplechases held at Falmouth on St. Patrick's Day of 1863 (32).

Quoits, a game similar to our present day horseshoes, was a popular form of recreation for the common soldier. The object of the game was to throw a large ring around a peg stuck in the ground. The diary of an Indiana boy noted in March 1862 that "there was nothing going on in camp, but the pitching of quoits (3)."

Foot races, hurdle races, and throwing of heavy weights were sometimes held in conjunction with the celebration of holidays. The Fourth of July, 1862, found the men of the 1st Maine Cavalry having foot races and other track and field events as part of their celebration on the anniversary of the signing of the Declaration of Independence (37).

Miscellaneous

One activity which was mentioned with surprising frequency by the soldiers of both North and South was snowballing. Most of the snowball fights were conducted on regular military tactics and were held between various companies or brigades. Often during these sham battles, the military units would be commanded by their officers. When there was an adequate snowfall, the impromptu battles appear to have been one of the favorite forms of winter recreation for the Civil War soldier.

These snowball fights were not child's play, and there were many soldiers who reported serious injuries inflicted during the excitement of a snowball battle. A Confederate soldier reported that snowball fights became regular occurences in the Army of Northern Virginia and had to be stopped because the men were having their arms and legs broken (4). One Confederate cavalryman wrote that "the snowballs were made as hard as possible and were capable of inflicting serious injury" (20). One soldier philosophized about the snowball fights when he wrote: "If all our battles could terminate the way our snow battles did it would be a great improvement on the old slaughtering plan" (15).

When there were ladies available and the musicians of the camp were willing to play, dancing emerged as one of the favorite pastimes of the soldiers of both armies. Dances were often held outdoors when no other suitable place was available. An Ohio volunteer recalled that the men of the 3rd Ohio held grand dances on the green in front of the rows of tents. He contended that these dances helped the soldiers to forget for a moment the hardships and dangers of war (11).

Band music appears to have played an important role in the life of the Civil War soldier. Each regiment usually had its own band which often played as the men marched into battle or in camps in an effort to bolster the sometimes sagging morale of the soldiers. A sergeant in the 3rd Michigan Volunteer Infantry attested to the popularity of band music when he wrote that "the soldiers love music, and listen to the strains of the beautiful military bands of which we have plenty in our army" (16).

The soldiers on both sides sang what was in their hearts. These men of almost one hundred years ago sang about the same things the soldiers of recent wars have sung about—home, mothers, sweethearts, the daily anxieties and nightly dreams. There was practically no difference in the subject matter between the songs of the Northern and Southern armies. One soldier in a letter home to his wife commented that "the men had such a gay time singing in camp that you would never believe they were going down South to fight Rebels (1)."

Some sports and recreational activities were mentioned by the soldier correspondents only rarely. Two are included here merely as evidence that they took place. Blanket tossing was described by a Pennsylvania soldier as a popular activity among the men of his regiment (34). In gander pulling, horsemen riding at full tilt attempted to catch the heads of live ganders that hung by their feet from a point barely within the rider's reach. Gander pulling, featured at dress parades and other occasions, aroused great enthusiasm among the soldiers (44).

Discussion

The investigation revealed 34 sports and recreational practices engaged in by the Civil War soldiers. The sports and recreational practices discovered during the course of study were participated in by a large proportion of the common soldiers and officers on both sides. Almost every source investigated mentioned some sport or recreational practice engaged in by the author or his comrades.

Some activities were engaged in more widely than others. Card playing, singing, hunting, fishing, swimming, baseball, and snowball fights had more participants than fencing, target shooting, boating, and chess.

Although there was evidence to show that both officers and men participated in most activities mentioned, officers tended toward such activities as horseback riding, fencing, target shooting, and horse racing. The common soldier. Also the game was not strenuous and could be played for relaxation boxing, baseball, free-for-alls, and snowball fights. This is accounted for in part by the fact that the activities selected by officers were those more directly concerned with the business of war and, therefore, more befitting the dignity of an officer.

Participation in the sports and recreational practices discovered most often took place during periods of inactivity, such as winter quarters, in camp during training, and in the field during the long lapse of time between battles.

Probably the most popular and most widely engaged in of all recreational activities, both North and South, was card playing. This popularity might be attributed to the fact that cards were easily carried and available to the soldier. Also the game was not strenuous and could be played for relaxation after a hard day on the drill field, a forced march, or an exhausting battle. It also seemed to satisfy man's desire to wager a gamble.

Baseball, or the similar game of town ball, appears to have been the most popular of all active sports engaged in by Union and Confederate troops during the war. Civil War baseball was played under a variety of rules and in a variety of ways. Baseball seems to have been more popular among New England troops than with men from any other section of the country. This might be partly because the game had its origin in the Eastern states and, therefore, spread more rapidly and enjoyed greater popularity in that section. Town ball, the Southern version of baseball, was predominately played by Confederate troops.

Swimming, fishing, and hunting were quite popular country sports with the men of both sides. The sporting urge was sometimes secondary to those of cleanliness and hunger.

The Civil War soldier loved music. Singing, dancing, and band concerts were popular forms of amusement in the camps of both armies.

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Effect of Isometric and Isotonic Exercise Programs upon Muscular Endurance

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Abstract

Two groups of ten subjects, each enrolled in the required program, were equated on the basis of the scores on the Arm Strength Index. Group I participated in a weight training program, and Group II performed the 13 exercises of the Commander Set, both groups meeting twice a week for eight weeks. Both groups showed statistically significant improvements in chinning and dipping ability and consequently in the Arm Strength Index. The difference between the means of improvement of the two groups was not statistically significant.

CONSIDERABLE RESEARCH has now been carried out on the efficiency of weight training programs for purposes of developing muscular strength and endurance (1, 2, 3, 8, 10). Such programs are essentially dynamic (isotonic) in nature.

Due to the findings of Hettinger and Muller (6), however, interest has recently been engendered in various forms of static (isometric) exercise and its effect upon muscular strength (14, 17, 18). Researchers elsewhere (3, 4), although achieving significant results in strength increase as a result of isometric training, were not able to approximate the findings of Hettinger and Muller. Other studies (11, 16) are contradictory in their conclusions.

Interest in these studies has in the main been concerned with the development of muscular strength rather than muscular endurance. To date there appear to be no data available on the effect of isometric exercise on muscular endurance.

Muller (12) states that vascularization is not markedly improved by static training and that ventilation and circulation to the increased muscular power must be acquired by ways other than static muscular training. Thus one would assume that muscular endurance dependent partially upon the efficiency of capillary circulation would not be significantly improved by a program of static training.

The purpose of this study, therefore, was to determine the relative effects of an isometric exercise program, the Commander Set (a series of static exercises developed by the late Commander Giauque, USN, and Arthur H Steinhaus), and a regular isotonic exercise program of weight training, upon muscular endurance as measured by the Arm Strength Index.

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The Commander Set program (15) requires no equipment and entails a fraction of the time to complete in comparison with a regular weight training program. Should investigation show this program to be of equal or greater value than the regular weight training program as a builder of muscular endurance the advantages would be obvious. But as Karpovich (6) says in reference to previous isometric studies:

> It is hard to accept these reports, because they apparently contradict everyday experience. Just think about muscle men working one to two hours a day for at least three days a week in order to develop strength. Maybe they are just wasting their time. Maybe!

Procedure

The parallel group technique was used, in which both groups were subjected to different programs at the same time. Twenty students enrolled in the required program at the University of British Columbia were selected and tested on their performance in high bar chinning and parallel bar dipping. The age and height of each subject were also obtained. The group was then divided into two groups of ten, equated according to their scores in the Arm Strength Index devised by Rogers and reported by Mathews (9) (I = [Chins + Dips] [Weight/10 — Height — 60]). All testing procedures and specifications were as outlined by Mathews.

Group I, the weight training group, used standard weights and followed a standard exercise routine. Loadings used were calculated on the subject's ability to perform a minimum of five and a maximum of ten repetitions.

Group II, the Commander Set group, carried out the 13 exercises as outlined by Steinhaus (15). Maximum contractions were held for six seconds in each exercise position. The exercises were carried out only once on each exercise day.

Both groups met twice a week at the same hour on the same day for a period of eight weeks. Both groups were tested on the first day of the program and retested following 16 exercise periods. Testing conditions were identical in each case. All subjects were asked not to take part in any other weight training courses during the period of the study.

Results

The statistical treatment of the results dealt with the mean increases in each group for various measures and with the difference between the means of improvement of the two groups. Results were accepted as significant at the 5 percent level of confidence.

Height and Weight. There was a mean increase of 0.55 in. in the height of the subjects in Group I and a corresponding mean increase of 0.45 in. in Group II. Subjects in Group I showed a mean weight increase of 4.35 lbs. whereas the subjects in Group II averaged a gain of 1.95 lbs. None of these differences was statistically significant.

Performances on Tests. The mean increases, for each group, in the three strength measures, are presented in Table 1. Also shown are the standard error of difference and the t ratio for each.

Table 2 sets forth the differences between the groups in the final test in dipping, chinning, and arm strength index.

TABLE 1.—GROUP INCREASES IN MEASURES OF DIPPING, CHINNING AND ARM STRENGTH INDEX

	M_1	M_2	M_1-M_2	SE Diff.	t ratio
Dipping Strength					
Group I	6.2	10.3	4.1	1.3	3.1[b]
Group II	6.7	10.3	3.6	1.4	2.6[c]
Chinning Strength					
Group I	5.3	8.7	3.4	0.94	3.6[a]
Group II	5.7	8.9	3.2	1.2	2.7[c]
Arm Strength Index					
Group I	321.0	550.1	229.0	54.25	4.22[a]
Group II	316.5	500.5	184.0	67.0	2.75[c]

[a]Significant at the .01 level of confidence.
[b]Significant at the .02 level of confidence.
[c]Significant at the .05 level of confidence.

TABLE 2.—DIFFERENCES BETWEEN GROUPS IN FINAL TEST IN DIPPING, CHINNING, AND ARM STRENGTH INDEX

	M_1	θ	SEM	SE Diff.	t ratio[a]
Dipping Strength					
Group I	10.3	3.0	0.9	1.42	0
Group II	10.3	3.5	1.1		
Chinning Strength					
Group I	8.7	1.6	0.5	1.12	0.17
Group II	8.9	3.2	1.0		
Arm Strength Index					
Group I	550.1	96.0	30.0	63.5	0.78
Group II	500.5	183.0	56.0		

[a]None of the t ratios was statistically significant.

Discussion

The analysis and the results obtained show a definite trend. Both groups improved significantly in chinning and dipping strength and consequently in the Arm Strength Index. Group I showed statistically significant gains at the .01 level of confidence in both chins and arm strength, and at the .02 level of confidence for dips. Group II, on the other hand, showed a statistical-

ly significant increase in chins, dips and arm strength at the .05 level of confidence. The differences between the means of improvement were not significant for either of the three items.

It should be mentioned at this stage that the group training with the Commander Set table of exercises spent only ten minutes per exercise period in training, whereas the group training with weights required three times the amount of time, i.e. 30 min., to complete their exercise program. Fundamentally, it appears that both exercise programs bring about resultant muscular endurance improvements in the restricted areas investigated.

Some reference must be made to the fact that the group of subjects used was, in the main, completely inexperienced in weight training programs. Just how far these improvements could be made to continue with respect to either type of exercise program remains problematical and open to further study.

It is interesting to note that the group participating in the Commander Set program did so with enthusiasm and did not complain of the effects noted by Rasch and Morehouse (14).

Summary

Two groups of ten subjects each enrolled in the required program at the University of British Columbia were equated on the basis of the scores on the Arm Strength Index. Group I was placed on an eight-week regular weight training program. Group II performed the Commander Set group of isometric exercises for the same period of time. Both groups met twice a week on the same day and at the same hour. No other weight training or exercise programs were undertaken by any subject during the experimental period. At the conclusion of this period all subjects were retested for the same items and under the same conditions.

The findings may be summarized, as follows:

1. Both groups showed statistically significant improvements in chinning and dipping ability and consequently in the Arm Strength Index.
2. Group I showed statistically significant improvements at the .01 level of confidence in chinning and at the .02 level of confidence in dipping.
3. Group II showed statistically significant improvements at the .05 level of confidence in both chinning and dipping.
4. Both exercise programs brought about a statistically significant improvement in muscular endurance of the upper arms. The regular weight trained group showed a tendency toward greater gains, although statistically the difference between the means of improvement of the groups was not significant.

Considering the time required to complete the Commander Set exercises (10 min. per exercise session), the results were most encouraging. The fact that no equipment is required for this program indicates possibilities for the out-of-gymnasium situation. The results of this study suggest wide possibilities for isometric exercise programs in areas other than pure strength measurements, and further work in the field is clearly indicated.

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Stimulus Complexity, Movement Complexity, Age, and Sex in Relation to Reaction Latency and Speed in Limb Movements[1]

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Abstract

Reaction latency and time required for basic limb movements made at maximal speed were measured in 402 subjects including both sexes and several ages within the range 8–30 years. Variation of stimulus type and complexity as well as movement type and complexity had no influence on the amount of correlation between reaction and movement times. Neither age nor sex influenced the amount of correlation, which was close to zero under all conditions even though reaction and movement time reliabilities were high. It was shown that differential conditions of "set" and/or other factors could cause the appearance of correlation. Women reacted slower than men, but the difference (less than .01 sec.) was considered unimportant. They averaged 22 percent slower in movement time than men. Subjects less than 18 years of age reacted and moved slower than adults.

CURRENT THEORIES of reaction latency and movement speed suggest that individual differences in these two phases of neuromotor response should be essentially uncorrelated. It has been held that response latency is determined by the nature and complexity of a stored neuromotor "program" or motor memory that requires time to be selected and read out to the motor nerves (7). The speed of a movement is theoretically determined by a different factor, namely strength in action, which is controlled by the effectiveness of the program in causing the appropriate muscles to create or apply force to the limbs and thus cause the movement (3, 8). It is thought that under special circumstances the influence of tertiary agents may be superimposed causing a moderate correlation between reaction time and net movement time that may be positive under certain conditions (4, 11) or negative under other conditions (9), as will be explained in a later section of the report. The amount of correlation does not seem to be dependent on the part of the body (arm or leg) that is moved or on the direction of the movement (10, 16). Adequate reviews of previous research are available (10, 13).

Recent studies have raised such questions as whether the correlation between reaction time and movement time is different in women and men,

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whether it is different in college students than in other age groups, and whether the fundamental theoretical relationship is one of a high positive correlation that has been attenuated by other factors or a basic zero correlation that is sometimes increased to a small or moderate value by tertiary influences. Some of the recent factual evidence bearing on these questions seems to be conflicting, and on the whole the facts available are somewhat limited in scope (1, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18).

While the early studies indicated that women react slower than men, there is apparently no theoretical reason why they should (4); there is need for more extensive data to determine if this type of sex difference is consistent. There is only a small amount of evidence on the comparative maximal speeds of men and women in a basic movement. Here, theoretical reasons indicate why women should be slower (3). More extensive data on this sex difference are needed. The relatively slow reaction time of children as compared with adults has been well established for many years. While investigation of their comparative speed in a basic standardized movement is a recent development, the few studies that are available agree in reporting that they are considerably slower than adults (1, 14).

The present investigation is particularly concerned with determining, under a comprehensive set of conditions, the amount of correlation between individual differences in RT and MT. The experiments to be described tested RT and MT. Two signal modalities were used (auditory and visual); there were two classes of stimulus conditions (simple and discrimination). The nature of the movement of a particular limb was varied from simple to complex. Results with subjects of both sexes were compared, and the influence of maturation was considered over the range from elementary school age through college age to adult status. Mean scores of both RT and MT received attention.

The various methods and apparatus employed in the study have been fully explained in the publications cited and will be given only a minimal description here as the need develops.

In all of the experiments there was a warning signal. A few seconds later at chance ordered intervals ranging from 1 to 4 sec. to avoid anticipation errors, the experimenter operated a key which caused the reaction stimulus to occur and simultaneously started the reaction chronoscope. The subject responded by making the prescribed movement as quickly and forcibly as possible. As he moved, his hand left the double-action reaction key, which stopped the RT chronoscope and started the MT chronoscope. As he completed the movement with a normal follow-through, his hand touched the target, which was a string, a small lightweight celluloid rectangle, or a tennis ball hanging on a string. In all cases, touching the target (even very lightly) operated a sensitive pull-out switch and thus stopped the MT chronoscope. Both chronoscopes were Standard Electric Type S, with .01 sec. dial divisions; their calibration and consistency were checked at this laboratory.

For purposes of statistical evaluation of the correlations, a type of variance analysis seemed most appropriate because the comparisons sometimes involve

more than two groups. All RT-MT correlations are of the product-moment type. They have been converted to the equivalent z's, which makes it possible to compute the mean square error for all variance estimates as $\sigma_z^2 = 1/(N - 3)$ where N is the number of individuals in the correlation sample. Since this error term is a parametric value, not an estimate, the number of degrees of freedom in the denominator of the resulting F ratio is infinity.

Both RT and MT score distributions tend to be skewed. They were normalized by converting to reciprocals (i.e., speed scores) in the case of the first sample (Movement A_1, Table 1). The correlation was .003, compared with .013 using the unconverted RT-MT scores. In the second sample (Movement B, men) the correlation was —.316, compared with —.323 using the unconverted scores. Such small differences between the two methods were not considered adequate to justify the conversion, so the unconverted RT and MT scores have been used throughout the study except where noted.

Results

Movement Complexity. For all four movements, the stimulus was an auditory signal preceded by the usual warning signal with a foreperiod of varied duration. All subjects were college undergraduates. Both men and women were tested (except for Movement A_1), yielding the results presented in Table 1. Different subjects were used for each movement, except for the use of the same sample in Movements B and C. Movement A_1 was a horizontal forward arm swing of 117 cm. to a string target (2). Movement B was an upward and forward thrust of 30 cm. to a ball-grasp target, while C started with an upward and lateral movement, reversed to a lateral downward movement and again reversed to the forward thrust (7). Movement C_1 was of a complexity intermediate between B and C, involving only a single reversal of direction (4).

TABLE 1.—INFLUENCE OF MOVEMENT COMPLEXITY ON REACTION TIME, MOVEMENT TIME AND THE RT-MT CORRELATION IN COLLEGE MEN AND WOMEN[a]

	Movement A_1	Movement B		Movement C_1		Movement C	
	Men N = 62	Men N = 30	Women N = 30	Men N = 40	Women N = 40	Men N = 30	Women N = 30
Reaction							
M	.225	.195	.205	.213	.238	.204	.219
σ	.033	.026	.026	.056	.071	.031	.034
r_{11}	.912	.914	.931	.909	.899	.936	.967
Movement							
M	.195	.093	.130	.270	.360	.481	.522
σ	.022	.024	.027	.059	.067	.079	.094
r_{11}	.942	.919	.964	.917	.902	.966	.976
Correlation							
r_{12}	.013	—.323	.104	.201	.168	.176	.292
z_{12}	.013	—.335	.105	.204	.170	.178	.301

[a]Time units in seconds. An auditory stimulus was used. The symbol r_{11} refers to the reliability coefficient; r_{12} designates the correlation between RT and MT.

The average of the z's (and the average r_{12}) for these 202 individuals is .091, which obviously does not differ appreciably from zero. Moreover, as shown in Table 2, there is no significant influence of movement complexity or sex on the size of the RT-MT correlation. The largest complexity effect is in the men and the largest sex effect occurs in Movement B, but even in these cases considered separately the results fail to pass the liberal 5 percent test of significance.

TABLE 2.—VARIANCE ANALYSES OF THE INFLUENCE OF MOVEMENT COMPLEXITY AND SEX ON THE RT-MT CORRELATION

Source of variance[a]	Complexity						Sex				
	Men			Women			Movement B			Pooled Movements	
	df	MS	F	df	MS	F	df	MS	F	MS	F
Between	3	.0616	2.09[b]	2	.0100	0.30	1	.0968	2.62[c]	.0077	0.52
Error	∞	.0295	———	∞	.0337	———	∞	.0370	———	.0149	———

[a]Using the values of z obtained from the intercorrelations r_{12}.
[b]An F of 2.60 is required for significance at the 5 percent level.
[c]An F of 3.84 is required for significance at the 5 percent level.

Stimulus Complexity. The apparatus and method used in an earlier study (6) were modified so that the random foreperiod intervals were automatically controlled by an electronic device, and another chronoscope was added so that both RT and MT could be measured. Since the experiment required discrimination between stimuli as tested by choice of correct movement, two visual stimuli were used. An orange light or blue light was presented in a predetermined random order. The blue light required hitting a ball with a table tennis paddle, using a backhand stroke. The orange light required the subject to reach forward and hit a different ball with his open hand, dropping the paddle during the movement. Prior to the discrimination tests, a series of measurements was made using only a simple situation, namely, the orange light and the forehand movement. While there may have been some difference in movement complexity, the major variable was, of course, the simple vs. discrimination stimulus situation.

The subjects were college undergraduates as in the movement complexity experiment. A new sampling of 100 individuals was used; half were men and half were women. Each individual did all three parts of the test. Only the last 8 of 25 trials in each situation were used in the analysis, in order to minimize the practice effects that typically appear in discrimination experiments.

The factual results are given in Table 3. The average RT-MT correlation for this sample of 100 individuals is .023. Since the correlations are so very low, there seems to be no point in going through the steps of a formal analysis to establish that the obtained RT-MT correlations are zero within the limits of sampling error. Considering also the results of the movement complexity

TABLE 3.—INFLUENCE OF STIMULUS COMPLEXITY ON REACTION TIME, MOVEMENT TIME AND THE RT-MT CORRELATIONS IN COLLEGE MEN AND WOMEN[a]

	Simple Stimulus		Discrimination and Choice			
	Movement D		Movement E		Movement F	
	Men	Women	Men	Women	Men	Women
Reaction						
M	.227	.231	.406	.403	.385	.387
σ	.027	.030	.056	.067	.049	.049
r_{11}	.921	.902	.937	.958	.963	.939
Movement						
M	.232	.249	.354	.373	.173	.241
σ	.031	.034	.043	.051	.042	.056
r_{11}	.922	.907	.951	.934	.966	.919
Correlation						
r_{12}	.112	−.092	−.103	−.123	.046	.025
z_{12}	.113	−.092	−.104	−.124	.046	.025

[a]The samples consisted of 50 subjects in each sex group. All subjects were tested with all three movements. The stimulus was visual. Time units are seconds. The symbol r_{11} refers to the reliability coefficient; r_{12} designates the RT-MT correlation.

experiment, it seems clear that this outcome is not specific to some particular type of stimulus or movement situation, or to the sex of the subjects.

Maturation. Data on Movements B and C for males of various ages were presented in another report (7), but were not analyzed statistically with respect to the influence of maturation on the RT-MT correlation. With the addition of several individuals and a rearrangement of the subjects from the college and adult groups, five subgroups of 20 individuals each became available (see Table 4). The subgroups were composed of the designated ages within a range of one year in the three younger groups and within a range of two years in the two older groups.

The RT-MT correlations from Table 4 have been fitted by the method of least squares with the linear regression line of age on the z values. In the analysis shown in Table 5, the total variance of the observed z values as between the various ages has been broken up into the variance of the z values predicted by this line (designated linear) and the residuals between the observed and predicted values. The error term is the parametric value for the error of z for the subgroup sample size as explained earlier. The average z value (and the r value) for the sample of 100 individuals is .092 for Movement B and .133 for Movement C. Neither differs significantly from zero.

The data presented in Tables 4 and 5 show that the statistical evidence fails to support the concept of a maturation influence, either linear or nonlinear, on the RT-MT correlation within the range 8—30 years. This finding is evidently not specific to a particular movement, since two kinds of movements have been used, and it does not seem to be limited to the particular subject samples employed. For example, Pierson (13) reported the RT-MT correlations for a large number of subjects, using subsamples of 20 individuals. Using his data for the age range 8–33 years (which is comparable to the

TABLE 4.—INFLUENCE OF MATURATION ON REACTION TIME, MOVEMENT TIME, AND THE RT-MT CORRELATION IN MALE SUBJECTS[a]

		8 yrs.	12 yrs.	18 yrs.	24 yrs.	30 yrs.
Movement B						
Reaction	M	.275	.214	.191	.192	.188
	σ	.042	.035	.029	.031	.022
Movement	M	.174	.097	.081	.087	.092
	σ	.043	.023	.021	.025	.018
Correlation	r_{12}	.166	.212	.080	.165	—.168
	z_{12}	.168	.215	.080	.167	—.170
Movement C						
Reaction	M	.295	.226	.202	.208	.198
	σ	.026	.033	.031	.027	.023
Movement	M	.762	.493	.399	.430	.418
	σ	.131	.108	.114	.098	.077
Correlation	r_{12}	.420	.072	.142	—.088	.088
	z_{12}	.448	.072	.143	—.089	.089

[a]The samples consisted of 20 male subjects in each age group. Time units are seconds; r_{12} designates the correlation between RT and MT.

TABLE 5.—VARIANCE ANALYSES OF INFLUENCE OF MATURATION ON THE RT-MT CORRELATION

Source of Variance	Movement B			Movement C			Pierson Data	
	df	MS	F	MS	F	df	MS	F
Total	4	.0238	0.41	.0386	0.66	13	.0768	1.31
Linear	1	.0557	0.95	.0684	1.16	1	.0797	1.36
Residual	3	.0132	0.22	.0286	0.49	12	.0765	1.30
Error	∞	.0588	——	.0588	——	∞	.0588	——

TABLE 6.—VARIANCE ANALYSES OF INFLUENCE OF MATURATION ON QUICKNESS OF REACTION AND MOVEMENT

Source of variance		Movement B				Movement C			
		Reaction		Movement		Reaction		Movement	
	df	MS	F	MS	F	MS	F	MS	F
Total[a]	99	21.55	——	13.29	——	21.67	——	303.78	——
Age	4	269.50	24.3	140.45	17.7	322.24	38.4	4650.96	38.5
Error	95	11.11	——	7.93	——	8.39	——	120.75	——

[a]In hundredth second units.

range of the present data, and does not cut off his data at an unfavorable position), a variance analysis may be computed as shown in the right-hand portion of Table 5. Even though the degrees of freedom are nearly tripled as compared with the present study (because he used 280 individuals, which yielded 14 age groups over the range in question), there is no statistical evidence for either a linear or nonlinear variation of the RT-MT correlation with age for this range. Evidently college-age subjects are not unique with respect to the amount of RT-MT correlation, at least as compared with younger and less mature subjects down to age eight.

It should be pointed out that this generalization may not hold for elderly subjects. The total Pierson data (13), including subjects age 8 through 80 years, can be analyzed by the present method. Inclusion of the elderly subjects results in a statistically significant linear regression of the RT-MT correlation (in z form) on age. The regression line indicates very substantial correlations at the older ages, reaching $r = .62$ at age 60, and $r = .72$ at age 80. Possible reasons for the higher correlation with older subjects will be discussed later.

Sex Differences in RT and MT. The values of the conventional t ratios for sex differences in quickness of reaction range from 0.20 to 1.80, and are nonsignificant. However, if the squared standard deviations are averaged and divided by the composite N to compute the error variance of the sex difference, the result is $t = .0088/.00406 = 2.17$, which is statistically significant. Note that a single-tailed statistical hypothesis is appropriate here. It may be mentioned that this t value would prove to be equal to $t/\sqrt{F}$ as obtained in a variance analysis. The amount of sex difference is very small, less than .01 sec., so one is forced to the position that it is not of importance, even though it is technically significant.

Sex differences in speed of movement (MT) are much larger, ranging from .02 to .09 sec. in amount of difference and 2.0 to 8.0 in size of t ratio. Each of the six movement or stimulus situations therefore reveals a significantly slower movement time in the women subjects. The average amount is .045 sec., which is 22.3 percent slower than the men. This agrees with results obtained in another sample of college students reported in a recent study. Using the movement here designated A_1, the women subjects were found to be 17 percent slower than the men (3).

Influence of Maturation on RT and MT. The analysis presented in Table 6 shows that the slower RT's and MT's that characterize the younger age groups (Table 4) represent a statistically significant influence of the maturation factor. However, it can be shown that a difference of at least .03 sec. would be required for significance at the 5 percent level between age groups in either RT or MT for Movement B, using the error term from the variance analysis. The required difference for Movement C would be .04 sec. Since differences within the age range 18–30 years are definitely smaller than these critical values (Table 4), it would seem that it is the pre-18-year-olds who are influenced by the maturation factor. The reader is reminded that some of these age group data were included in another report concerned with a

different problem (7). In the present study, some cases have been added and the older age groups have been rearranged to afford a systematic experimental design, so that the variance analyses could be made.

TABLE 7.—DISTRIBUTION OF 80 WITHIN-INDIVIDUAL RT-MT CORRELATIONS

	Class Interval of z Values					
	—.51 or lower	—.50 to —.26	—.25 to —.01	0 to .24	.25 to .49	.50 and higher
Frequency observed						
Men	5	8	9	7	3	8
Women	2	7	7	12	7	5
Total	7	15	16	19	10	13
Frequency expected	8.0	12.8	19.2	19.2	12.8	8.0

Intra-individual Relationships. It is not difficult to visualize a situation in which individual mean scores in RT and MT are uncorrelated, while at the same time there is a tendency for correlation in the within-subject deviations. One of the several possible mechanisms might be variations in motivation about a normal mean value, influencing both RT and MT. Another might be variations in physiological state. The RT-MT correlations within each of the 80 individuals tested with Movement C_1 have been calculated for the last 10 trials, using reciprocal scores to avoid skewness.

Evidently there is no significant correlation in the present sampling. The average of the correlations for the men (using the z transformation) is —.027; for the women it is .050. The median values are —.102 and .077. The distributions of the z values, and the frequencies expected from the theoretical distribution of 80 samples of a parametric value of $z = 0$ and $n = 10$, are given in Table 7. The chi square computed from this table, combining the two tails with their adjacent columns as is usually done to secure an adequate value for the expected frequency, has the value .85. This fails to be significant when compared with the 5 percent criterion of 3.4 using $4—3 = 1$ degrees of freedom. As a matter of interest, it may be noted that there is no significant difference between the distributions for the two sexes.

Absence of a correlation between the within-individual variations in RT and MT might be explained by postulating that these variations are simply the result of measurement error. This possibility can be tested, since the variable errors of the instruments used (including observational error) are known to be $\sigma = .0069$ sec. for the RT chronoscope and .0067 sec. for the MT chronoscope. The total variances are presented and fractionated in Table 8. It is seen that the actual error of measurement $\sigma_e{}^2$ is trivial as compared with the variation observed within individuals.

Such intra-individual variation is a characteristic of behavior; it is not error in a biological sense. In a statistical frame of reference, designation of

TABLE 8.—FRACTIONATION OF RT AND MT VARIATION

		Men (N = 40)		Men (N = 40)	
		RT	MT	RT	MT
Total variability[a]	σ_x^2	14.99	39.42	13.39	48.60
True score[b]	σ_t^2	13.90	37.98	11.61	46.09
Intra-individual[c]	σ_i^2	10.39	13.96	17.25	24.66
Instrument	σ_e^2	0.479	0.447	0.479	0.447

[a] This is the variability of individuals using the average score of ten trials. The units are hundredth seconds.
[b] Between individuals, defined as $O_x^2 - (O_i^2\ O_e^2)/n$ where n is ten trials per individual, and x is an individual mean score.
[c] Within individuals, defined as $O_w^2 - O_e^2$ where O_w^2 is the average (for N individuals) of the variation of an individual's single scores about his own mean.

a particular source of variance as error is relative, and must be appropriate to a particular aspect of analysis. For example, individual differences are designated error in comparing the averages of two groups of individuals. However, if interest is centered on the amount of individual differences, the appropriate error term is the intra-individual variance. Similarly, if interest is centered on the amount of intra-individual variation, the appropriate error term is the observational and instrumental variance. (These three types of variance are of course cumulative when employed in the hierarchy of error estimates).

The data show that there is a surprisingly large amount of intra-individual variance. In the case of RT, it is in fact about as large as the individual difference variance (Table 8); in consequence the reliability coefficient for individual differences using single trials per individual is only .56 for men and .40 for women. It is of course common to average out the influence of individual differences in a group of subjects by computing the mean score of the group. Similarly, the statistical influence of intra-individual physiological or other changes can be averaged out by the use of individual mean scores. When this is done for the ten trials per subject of the Table 8 data, the reliability coefficients jump to .93 for men and .87 for women. While these correlations are so large as to suggest high self-predictibility for RT scores, it must be kept in mind that what is being predicted is the average individual scores rather than single reactions. Failure to appreciate this distinction has sometimes led to misinterpretation of results.

In the present case, it can be shown that since the correlation between individual single RT's is .56 for men and .40 for women, it follows that the index of reliability (which is the limiting value for the correlation between individual averages for many trials and individual single trials) approaches .75 for men and .63 for women. Thus the percent predictibility of one RT from individual averages is 56 for men and 40 for women; the unpredicted variances of 46 percent and 60 percent in single RT's represent the within-individual behavioral variance plus a small amount of measurement error. In the case of MT, the corresponding single trial reliability is higher in this particular sample; the coefficient is .72 for men and .65 for women. The statistical basis for the computations has been given elsewhere (5).

Discussion

The results of the present study, involving some 400 individuals varying in age and sex and tested under a variety of stimulus and movement conditions, offer strong evidence that the fundamental intrinsic correlation between RT and MT is essentially zero. The influence of other factor or agents may under special circumstances override this fundamental relationship, causing either a negative or positive correlation depending on the situation.

The experiment of Howell (9) furnishes an example of overriding. Using an extremely strong incentive to produce a fast total time (RT + MT), he postulated that individuals would differ in set, although he did not use that term. Some subjects would gain speed by an improvement in RT while others would gain it by improving MT, thus causing a negative correlation between RT and MT. Either method would yield a faster total time, thus permitting the avoidance of a severe electric shock. His results confirmed his expectation, since the observed RT-MT correlations ranged from —.369 to —.489.

Under other circumstances, set would theoretically cause a positive correlation. It has recently been reported (4) that individuals with a natural sensory set tendency average *faster* in both RT and MT when using that set than when using the motor set. Individuals with a natural motor set tendency are found to average *slower* in both RT and MT when using the sensory set as compared with the motor set. Since an unselected sample of subjects includes individuals whose natural set tendency ranges from strongly sensory to strongly motor, a positive RT-MT correlation should appear when all subjects are required to use the same set. It was found that in a sample of 80 subjects the correlation was significant, being .306 with enforced sensory set and .349 with enforced motor set.

Prior to the experiment, these subjects were given 15 trials using their freely chosen natural set in order to ascertain the set tendency of each individual. No further analysis of these trials was made at the time of the report (4). Although not of concern to the present investigation, it is interesting that when the group is split into a more sensory half and a more motor half in terms of the freely chosen set actually used in the 15 trials, the RT of the subjects who used mostly the sensory set averages 12.0 percent faster than the RT of the subjects who used mostly the motor set. This is a significant difference ($t = 2.0$). The MT is only 2.3 percent faster (not significant; $t = 0.7$). These results are consistent with the previously reported results with enforced set (4).

No determination of the RT-MT correlation under this natural condition was made in the other report, since this consideration was peripheral to the problem investigated. Since it is pertinent to the present discussion, the coefficient for the last 8 of the 15 natural trials has been computed. The value is $r = .185$, using the same method as in the original study, and does not differ significantly from zero. It may therefore be inferred that the significant positive correlations found in the set-imposed conditions were caused by the mechanism postulated above. It seems reasonable to suggest that the significant correlation of $r = .308$ in 50 college men recently observed by Wilson

(17) was caused by the same mechanism, since the conditions of his experiment would force some subjects into a sensory set.

In some circumstances the absence of adequate pretest practice theoretically can produce the appearance of a RT-MT correlation. Some individuals catch on quickly, and their scores are relatively stable right from the first. Others may be slow in both RT and MT in their early trials, requiring considerable practice before reaching a stable speed. To test this possibility, consider the experiment discussed above. In the male subjects, the mean RT was .222 sec. for trials 1–5 and .213 sec. for trials 8–15. It is of interest that in a subsequent experiment with enforced set using 80 trials, it had dropped to .201 sec. The corresponding averages for MT were .326 sec., .270 sec. and .239 sec. In the female subjects, the RT values were .249 sec. for trials 1–5, .238 sec. for trials 8–15, and .227 sec. in the later experiment; the MT values were .425 sec., 270 sec., and finally .239 sec.

It seems clear that there was definite mean improvement with practice in both RT and MT, and in both sexes. Each gain was significant. In the unpracticed subjects (trials 1–5), the RT-MT correlation turns out to be .548 for males and .331 for females. At the practice state represented by trials 8–15, these correlations have dropped to .201 and .168 respectively, and no longer differ significantly from zero. It seems reasonable to infer that the higher correlations found in the unpracticed state were caused by the mechanism postulated above. (Note that the correlations found in the 80 trials cannot be used for comparison, because they were obtained under conditions of enforced motor and sensory set as explained earlier).

Mendryk (11) has called attention to the theoretical possibility that in a group of subjects who are heterogeneous as to age, a positive RT-MT correlation is created because older or younger subjects tend to be relatively slow in both RT and MT. He found that when he combined his age groups into a single heterogeneous group, the correlation approximately doubled and became significant. Pierson (13) was aware of this possibility. When he used age-equated scores in both RT and MT his average correlation dropped from .56 to .31. In addition, it does not seem overly speculative to expect that older individuals, even within a narrow age range, would vary widely in individual impact of the aging process and of health status. In fact, his older subjects showed a tremendous increase in RT and MT variability (14). Presumably such factors would influence both RT and MT in a given individual, thus causing a positive correlation which would be superimposed on the normal zero correlation in the older age groups. Differential motivation among the subjects of a given experiment would also operate to cause a superimposed positive correlation. Among individuals of equal ability, a poorly motivated person would be relatively slow in both RT and MT and an exceptionally well-motivated person would be relatively fast in both.

Considering the results from subjects above approximately age 40 separately, only two sets of data on older subjects are currently available. The Pierson study reported correlations of .27, .82, .86, .59, .58, and .53 for his six groups of 20 subjects centering at ages 38, 43, 51, 61, 71, and 81 years.

The average r (using the z transformation) is .65. In the Mendryk study, the RT-MT correlations were .034 and .079 for two movements in 50 subjects of age range 40-55 years. Similar methods seem to have been used in the two investigations; the practice stage of the subjects was the same in both. It may be noted that the individuals tested by Mendryk were physically active in status, drawn from a university population; it is not known to the writer if the Pierson subjects were comparable.

For subjects covering the age range 8–35 years approximately, results from several independent studies are available. From the Pierson data, the average correlation for males (using the z transformation) is .28 for 280 individuals. This may be compared with correlations of .092 and .133 in the present study, using 100 subjects similar in age to those of Pierson, but employing two different movements. This is not a very serious disagreement. Mendryk, using the Pierson method (including his "representative scores" technique), reported correlations of .023 and .228 for two movements in 50 subjects, age 12, and .318 and .105 for two movements in 50 subjects, age 22. The average for his 100 individuals is .175 for the Pierson movement, and .167 for a longer movement.

Considering now the female subjects, there is the study of Youngen (18), who has reported an RT-MT correlation of r = .26 in 122 college women tested by the Pierson method, which provides adequate pretest practice. In the present study, the average correlation in 120 college women is .064. Here again the disagreement may involve technically significant differences, but the quantitative amount of difference is not serious. Accepting the correlation of .26 at face value, it represents only a small amount of relationship. As Smith (16) has emphasized, the percentage of individual difference variance that is common to both RT and MT is given by $r^2 \times 100$. This is only 7 percent for a correlation of .26, and is certainly too small to be of practical significance.

In terms of the theoretical concepts outlined in the introduction, it matters very little whether *the* RT-MT correlation is .26 or .28 or .33 or some other low value, or whether it is zero. The real issue concerns (a) whether the correlations that are observed probably stem from a common factor and are basically high theoretically, but have somehow become attenuated, or (b) whether it is not more reasonable to conclude that the nonzero correlations are deviations from a basic parametric value of zero. Several mechanisms have been postulated that would under special circumstances cause observed RT-MT correlations to deviate from a theoretical zero, and the factual reality of their operation has been demonstrated. It would seem that these mechanisms are adequate to account for the occasional occurrence of deviant values in excess of sampling expectations for a parametric correlation of zero.

The findings of the other recent studies using college men as subjects are straightforwardly consistent with the present results and with the position that the correlation between RT and MT is approximately zero. Clarke (1) reported it to be .057, Lotter (10) found an average correlation of —.14, Owens (12) obtained a value of .075 for the relationship, and Smith (16)

also found a low correlation, namely .11. The average of these is very close to zero. Most of the earlier studies also reported near-zero correlations. Keeping in mind that the concept of sampling error implies that an occasional statistically significant correlation must be expected even under the hypothesis of a near-zero parametric value, it would seem that the theoretical expectation of basic independence of individual differences in RT and MT has been adequately tested.[2]

Conclusions

The data of the present report, particularly when viewed in the light of the above discussion, would seem to justify the following conclusions:

1. Individual differences in reaction time and movement time are almost completely independent and uncorrelated in terms of the fundamental relationship.
2. This generalization applies to subjects of either sex and of any stage of maturity within the approximate age range of 8 to 35 years.
3. The low correlation is not dependent upon any particular type of stimulus or movement.
4. Variations in reaction time within the individual appear to be unrelated to variations in movement time.
5. Special conditions of set and/or other factors influencing individuals differentially may occlude the fundamental relation, causing the appearance of either a positive or a negative correlation depending on the conditions.
6. The average reaction time is probably slower in women than men, but the difference is too small to be considered important.
7. Women are considerably slower than men in maximum speed of basic limb movements. This holds for both simple and complex movements.
8. Younger subjects (below age 18) are slower than adults in both reaction time and movement time.

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[2] Two other studies have appeared since this article was written. W. R. Pierson and P. J. Rasch ("Generality of a Speed Factor in Simple Reaction and Movement Time." *Perceptual and Motor Skills,* 11:123-28, October 1960) found an average correlation of .33 between RT and MT in 32 men who made 9 movements. F. M. Henry ("Reaction Time—Movement Time Correlations," *Perceptual and Motor Skills* 12:63-66, February 1961) reported a correlation of .02 in 120 men and demonstrated that the RT-MT regression is linear.

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Relationship of the Interval of Time Between Paired Auditory and Visual Stimuli and Reaction Time[1]

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Abstract

The purpose of this study was to investigate the relationship of the interval of time between paired auditory-visual and paired visual-auditory stimuli and hand reaction time. Two groups of ten subjects each were used, and the interval of time between stimulus presentation was manipulated within the range 50 to 500 milliseconds. The results supported previous reports citing characteristic delays in second response reaction times when the interval between stimulus presentation was 0.5 seconds or less. An analysis of the compatibility of results with proposed theories concerning the psychological refractory period as the cause of these characteristic delays was made.

MANY STUDIES concerned with various aspects of human response mechanisms have been made. Recently the limitation in the rate at which human responses can be made efficiently has grown in importance. It has been shown that when discrete stimuli are presented in pairs at irregular intervals, the reaction time to the second of the stimuli separated by an interval of 0.5 seconds or less tends to be longer than the reaction time to the first stimulus. This additional delay in an individual's reaction time to the second of two stimuli, when such stimuli are presented in close proximity to another, has been called the psychological refractory period (8).

Although there is some question about the theoretical causes for the existence of the phenomenon, studies seem to agree that under certain conditions the reaction time to the second of a pair of stimuli is often longer than the reaction time to the first. The question is not whether there is such an effect, but rather, what are its causes and the limits and magnitude of its effects, and what implications does it have for basic theory considering the functioning pattern of human response processes.

An investigation by Slater-Hammel (6) considered the problem in the light of knowledge then available concerning the psychological refractory period. A subsequent research by Davis (3) made note of the fact that previous investigations used sequences of stimuli in the same sense modality. In an attempt to investigate further the nature of the intermittency of human

[1] This study was made in partial fulfillment of the requirements for the degree of Doctor of Physical Education in the School of Health, Physical Education, and Recreation, Indiana University, Bloomington, August 1959 under the direction of Arthur T. Slater-Hammel.

responses, he conducted an experiment using two different sense modalities, visual and auditory. The results suggested a human being functioning as "a single channel through which information from both sense modalities had to pass before appropriate responses are organized." The pattern of delays at short intervals was found to be the same as delays when only one sense modality, the visual, was used.

The results seemed to discount the possibility that by sending in signals via different sense modalities the human operator could utilize different and independent channels for the processing of information and thus eliminate the psychological refractory period. One difference noted from an earlier experiment (2) using only one sense modality was that delays at short intervals were superimposed upon the constant lag of visual reaction time behind auditory reaction time. It was proposed by Davis that the same source of delay exists regardless of whether or not the same or different sense modalities were used. The assumption pointed to a single channel conception of functioning to such stimuli.

Realizing the importance that the psychological refractory period has for athletics and physical education, and in view of the fact that basic theory concerning the phenomenon is not yet completely advanced, the need for a further study seemed evident. Briefly stated, the purpose of this study was to investigate the relationship of the interval of time between (a) paired auditory-visual stimuli and (b) paired visual-auditory stimuli and hand reaction time. Davis (3) proposed just such an experiment to test several tentative postulates concerning both confirmations and divergencies of present theories.

Procedures

Twenty male Indiana University graduate students were randomly assigned by pairs into two experimental groups. The subjects were former athletes, and their ages ranged from 24 to 44 years with a median age of 30 and mean age of 31 years. In one group the order of stimulus presentation to which paired responses off hand telegraph keys had to be made was in the sequence auditory-visual. In the other group, the sequence of stimulus presentation was visual-auditory.

In the group auditory-visual, each subject was given a total of ten experimental sessions, with the completion of only one session a day allowed. The first four test days consisted of simple reaction time trials for each hand to both visual and auditory stimuli. Each day 200 trials were secured on each subject distributed 50 trials each for right hand to visual and to auditory stimuli, and 50 trials each for left hand to visual and to auditory stimuli. Thus, 800 trials distributed 200 trials each for the four separate hand and stimulus combinations possible were secured on each subject over the four simple response test days.

Next, six sessions of responses to paired stimuli in the auditory-visual sequence were given. Subjects always responded with the right hand to the initial stimulus in the auditory modality; the second response with the left

hand was always made to the subsequent visual stimulus. On each test day, five series of 20 paired responses with five catch trials for the second response member randomly assigned to each series were given. On all occasions, the auditory stimulus was presented, and a response from the subject of right hand off the right key was expected. On a catch trial, however, the auditory signal was presented as usual, but the second stimulus of light was not presented, and a response from the subject with his left hand was to be inhibited.

The interval between the auditory and visual stimulus presentation was varied from 50 to 500 msec. The range between 50 to 500 was divided into values differing by 50 msec. so that in any series of 20 paired responses each value of the interval occurred twice. The order of interval presentation and catch trials was randomly varied. Each day a total of 100 paired responses to auditory-visual stimuli resulted in ten measures at each interval of time between stimulus presentation.

The specified time intervals for both simple and paired response situations were exactly the same as used by Davis (3) in order to make a comparison of results more applicable. The second experimental group of visual-auditory followed the same procedure except that the sequence of stimulus presentation in paired responses was in the visual-auditory order.

Analysis and Results

The unit of analysis was a treatments by subjects design. With certain modifications, the T $\times$ S design was like the one described by Lindquist (4).

Since the subjects were originally randomized into two groups from a common population of 20 male graduate students, the mathematical model for the T $\times$ S design in this investigation is a mixed effects model (1), i.e., the treatments are the fixed effects and the subjects the random effects. Hence, generalizations about treatment effects can be aggrandized to the population like the one from which the subjects were originally drawn. Although this is not a markedly broader basis of inference, it is nevertheless superior to the fixed effects mathematical model. In the fixed effects model, neither the treatments nor the subjects are selected at random and generalizations are restricted to the specific population of subjects and the treatments employed.[2]

Prior to an analysis of the data the significance level of 5 percent for rejection of null hypotheses was decided upon. All interpretations of results were based upon this probability level.

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[2] The statistical analysis is valid regardless of the method of subject procurement employed. The effect of not utilizing a random sampling technique for subject procurement is that the results of the investigation are statistically limited to the particular subject population employed. If an investigator wishes to aggrandize the results to a larger hypothetical population he must do so as a scientist and not as a statistician. Whether the technique of subject procurement was random or opportunistic, however, does not invalidate the statistical analysis made in the investigation (see also Arnold Binder's paper [1]).

SIMPLE REACTION TIME

The simple reaction time measures analyzed were the means obtained on each subject for each of the four simple response laboratory periods. A separate analysis of variance was made on each of the four different sets of simple reaction times secured; i.e., right hand to light, right hand to sound, left hand to light, and left hand to sound.

On the basis of the over-all analyses of variance and the results of Tukey's procedures, reaction time measures for the last two simple response test days were pooled to secure reasonable estimates of well-practiced performance for each of the simple reaction time responses. The results are presented in Table 1.

Comparisons of simple reaction time for the same hand to the same stimulus modality between the experimental groups were made. There were no significant differences with t's ranging from .24 to 1.75.

TABLE 1.—MEANS AND STANDARD DEVIATIONS OF POOLED SIMPLE REACTION TIME MEASURES IN MILLISECONDS

Group	Right Hand To Light	Left Hand To Light	Right Hand To Sound	Left Hand To Sound
Light-Sound	$M = 169.89$	163.45	132.85	135.05
(N=10)	$\sigma = 19.31$	16.17	12.87	14.66
Sound-Light	$M = 176.34$	167.83	138.09	139.02
(N=10)	$\sigma = 15.06$	16.93	18.01	19.77
Total	$M = 173.12$	165.64	135.47	137.04
(N=20)	$\sigma = 17.61$	16.70	15.87	17.52

PAIRED REACTION TIME

Concurring with the logic and recommendation of Slater-Hammel (6) in a similar investigation, evaluation of practice effects upon paired responses was limited to an analysis of diurnal means for the initial (right) hand only. Paired right hand mean reaction times were analyzed by the analysis of variance technique. For each experimental group, obtained F values exceeded the value needed for significance at the .05 level, and it was concluded that there were significant differences in paired right hand reaction times between the six paired response test days.

Tukey's procedures for multiple comparisons of individual means in the analysis of variance technique were applied in each group. On the basis of the findings it was decided to pool the measures of the last three test days in each group to secure an estimate of reasonably well-practiced performance for right hand responses in the paired response situations.

To verify Davis' finding (2) that the initial reaction time in paired responses was normal, i.e., similar to the simple reaction time for that member, a comparison was made between the pooled mean reaction time for the right hand under paired and simple response conditions. In group auditory-visual, the difference between simple right hand to sound (138.09

msec.) and paired right hand to sound (147.22 msec.) was significant ($t = 3.94$); in group visual-auditory, the difference between simple right hand to light (169.89 msec.) and paired right hand to light (178.48 msec.) was significant ($t = 2.91$). In both groups, the results indicated that initial reaction time in paired responses was significantly longer than its corresponding simple reaction time measure.

As noted, a separate analysis of practice effects upon the left hand member in paired responses was not made. Left hand reaction time means at each of the intervals between stimulus presentation were pooled over the same days selected by Tukey's analysis of initial (right) hand responses. An analysis of variance was made using these pooled estimates, and the obtained F value in each group was significant at the .05 level. The subsequent Tukey's analysis indicated that left hand responses fell into interval groups in which performance improved significantly. In group visual-auditory, the interval groups separated were 50, 100, 150, 200, 250, and 300 to 500 msec. In group auditory-visual the interval groups separated were 50, 100, 150, 200, and 250 to 500 msec.

Pooled mean reaction time for each of the interval groups was compared with corresponding simple reaction time for the separate experimental groups. Significant t values indicated that the second reaction time in paired responses was significantly slower in all interval groups than its corresponding simple reaction time measure.

To further investigate the nature of these delays in the second response member, a trend test analysis discussed by Lindquist (4, p. 340-56) was made. According to Davis, the limits of the psychological refractory period are not expected to extend beyond the duration of the initial reaction time; that is, the second response should experience a progressive increase in reaction time by an amount equal to the progressive decrease in the interval between stimulus presentation only when the interval between stimuli is less than the initial reaction time. Hence, Davis' postulates do not call for proportional changes in the second response over the range of intervals 50 to 500 msec. employed in this study.

On this basis, it was decided to conduct the trend test analysis over the intervals 50 to 200 msec. for group auditory-visual, and over the intervals 50 to 250 msec. for group visual-auditory. It is important to note that this decision was based upon a qualitative analysis of underlying theory rather than upon a strict speculatory and quantitative analysis of the data secured.

The analysis made in testing the hypotheses of (a) no trend at all and (b) the trend is linear for left hand responses in the two experimental groups is presented in Table 2. As seen in this table, the obtained F values were significant. Thus, the hypotheses of (a) no trend at all and (b) the trend is linear for left hand responses were rejected at the .05 level in each experimental group. The evidence indicated a trend was present but rejected the hypothesis that the trend present was linear.

TABLE 2.—SUMMARY OF TESTS FOR PRESENCE AND LINEARITY OF TREND FOR LEFT HAND REACTION TIMES IN PAIRED RESPONSES

	Group Auditory-Visual			Group Visual-Auditory		
Source of Variation	df	Mean Square	F	df	Mean Square	F
Between Intervals	3	14,909.473	197.82	4	20,177.074	148.74
Between Subjects	9	3,118.091		9	4,526.684	
Residual	27	75.368		36	135.649	
Total	39			49		
Departure From Linearity	2	301.563	4.00	3	565.569	4.17
Error (Residual)	27	75.368		36	135.649	

The observed mean reaction times for left hand in paired responses were tested for goodness of fit to an a priori theoretical trend based upon Davis' predictive formula.[3] The hypothetical values derived from Davis' formula could differ from corresponding actual values obtained in either pattern or vertical placement. Hence, the goodness of fit analysis was composed of two separate hypotheses: (a) the pattern of actual values obtained was correctly described, and (b) the vertical placement of actual values obtained was correctly described. Table 3 summarizes the analysis for goodness of fit in each of the experimental groups.

The obtained F values were significant at the .05 level. Since both pattern and vertical placement hypotheses in the goodness of fit analysis were rejected in each experimental group, it was concluded that a priori formu-

TABLE 3.—SUMMARY OF GOODNESS OF FIT ANALYSIS FOR LEFT HAND REACTION TIMES IN PAIRED RESPONSES

	Group Auditory-Visual			Group Visual-Auditory		
Source of Variation	df	Mean Square	F	df	Mean Square	F
Departure From Pattern	3	1,074.047	14.25	4	1,887.362	13.91
Vertical Placement	1	96,737.060	1,283.52	1	201,041.405	1,482.07
Error (Residual)	27	75.368		36	135.649	

[3] According to Davis, if the interval between stimuli was less than the duration of the first reaction time, the second reaction time could be predicted by: $RT_2 = RT_1 + RT_n - I$, where RT_2 is the second reaction time, RT_1 is the first reaction time, RT_n is the normal reaction time for the second response member, and I is the interval of time between stimulus presentation in the paired response situation. If the interval between stimulus presentation was greater than the first reaction time, then no delay should occur.

lations of expected second response reaction times based upon Davis' formula were inadequate in describing either of the trends previously shown to be present for left hand responses in the paired response situations.

Discussion and Comparison of Results

The finding in each experimental group that initial (right hand) reaction time in the paired response situation was significantly slower than corresponding simple reaction time measures is similar to the results reported by Slater-Hammel (6), but is incongruent with expectations engendered by Davis' interpretation of Welford's (8) basic theory, and with Davis' own investigative results (2). The present findings are even more unexpected since the experimental procedures would seem to have favored the right hand in the paired response situation rather than the simple reaction time situation. In paired responses the initial stimulus and response always occurred and was not liable to the presentation of a catch trial in which the initial response might have to be inhibited, while in the simple response situation catch trials made the presentation of a stimulus and a required response an uncertainty.

The simple reaction time analysis indicated that none of the observed differences between groups for simple reaction time with the same hand to the same stimulus were significant. In effect, the observed differences between groups could be ascribed to chance sampling variations. Although the failure to reject a hypothesis does not constitute proof that the hypothesis is true—due to the unknown risk of a Type II error—the results would seem to reasonably justify considering the two experimental groups as being similar in the quality of simple reaction time measures. For purposes of comparison, the findings were interpreted as being a reasonable basis for the assumption that observed differences in paired responses for the two experimental groups were due to treatment effects and not to marked differences in the quality of simple reaction time measures.

A comparison of left hand reaction time in paired responses for each group is presented graphically in Figure 1.

Figure I generally substantiates at least a portion of Davis' investigative results and theoretical predictions. The same pattern of second reaction times was obtained regardless of the sequence of stimulus modality presentation. In either sequence, the longer reaction times occurred at the shorter intervals of time between stimulus presentation; as the interval between stimuli was increased in duration from 50 to 400 msec., second response reaction times improved rapidly. At the 450 and 500 msec. intervals, however, second responses tended to increase.

The observed increase in reaction time at intervals between stimuli 450 and 500 msec. is suspected to be due to an expectancy effect similar to the results by Slater-Hammel. According to Slater-Hammel's attempt to explain this effect, subjects are assumed able to identify the approximate limits of the experimental interval between stimulus presentation; when the subject

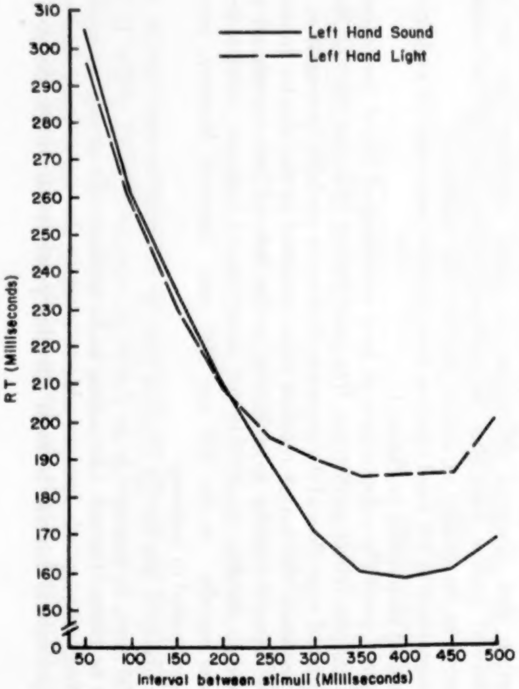

FIGURE I. Comparison of left hand reaction time measures in paired responses for each experimental group.

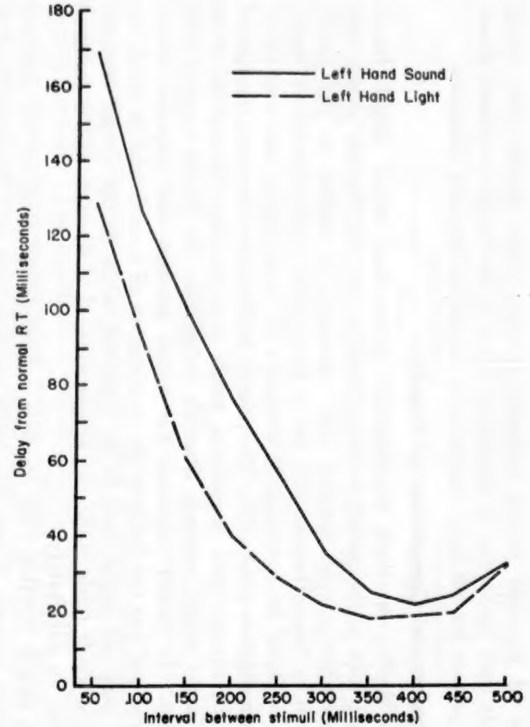

FIGURE II. Comparison of incurred delays in left hand reaction time measures for each experimental group.

anticipated a catch trial, he allowed his preparatory set to wane in the expectation that no response involving the second member would be called for. As a result, if a second stimulus actually did arrive the condition of partial unpreparedness apparently caused longer reaction times than usual.

An inspection of actual second response reaction times at interval 500 msec. showed that the majority of second response trials were similar to measures at intervals 350 and 400 msec., but that several measures were longer thus raising the arithmetic mean. This condition offers some support to the contention of a subject being caught in a state of partial unpreparedness when a catch trial was anticipated but a second stimulus actually did arrive at the longer intervals. The suspected expectancy effect is in evidence for the second response member in each experimental group, and suggests the effect is present regardless of the sequence of stimulus modality presentation.

The rate of improvement for left hand to light reaction time from interval 200 msec. on was not as marked as for left to sound. Part of this difference in rate of improvement might be due to Davis' conception of nonoverlapping central organization times, but part was probably due also to the inherent superiority of auditory reaction time over visual reaction time. Hence, left hand to sound had more improvement to make before it reached its best performance in the paired response situation.

As might be expected, there were no significant differences between left hand reaction times in paired responses for the two experimental groups from intervals between stimuli 50 to 200 msec. Values of t for these comparisons ran from .05 to .63. At interval 200 msec. a definite breaking point seems to have occurred with left hand to sound continuing to improve rapidly, approaching its fastest performance at interval 400 msec. Left hand to light reaction times also continued to show slight improvement and reached its fastest performances at interval 400 msec.

The differences between left hand reaction times started to increase from interval 200 msec. on. The t values for intervals 250 and 300 msec., however, were not significant being .52 and 1.65 respectively. The trend in results suggests that these differences are real, but apparently represent a transitional stage in which observed differences could not be demonstrated as being significant with the degree of precision available in this investigation. Beyond interval 300 msec, all differences between left hand reaction times for the two groups were significant with t values ranging from 2.54 to 3.07.

The evidence indicated that the pattern of second response reaction time is very similar regardless of the sequence of stimulus modality presentation. Hence, the possibility seems discounted that elimination of the characteristic delay due to the psychological refractory period could be realized by sending in stimuli via different sensory modalities. As suggested by Davis, the possibility that stimuli in different modalities could be dealt with independently by the central mechanisms—resulting in elimination of delays in the second response—is thus corroborated as unremunerative.

In another aspect of his experiment, Davis used an auditory-visual sequence of stimulus presentation and noted an additional delay, unaccounted

for by his theory, of approximately 60 msec. at the shorter intervals. It was suggested that this additional delay might be due to a time requirement of the central mechanisms to shift from the auditory to the visual modality instead of being due to the nonoverlapping central organization time concept.

In order to test the possibility that this additional delay was due to something other than the nonoverlapping central organization time theory, Davis suggested reversing the sequence of stimulus presentation to the visual-auditory order. The expectation in this situation would be a delay in left hand reaction times approximately 60 msec. longer than incurred delays in the auditory-visual sequence of stimulus presentation.

If no difference in delays resulted, then the argument that the additional delay noted at short intervals was due to a time requirement of the central mechanisms to shift from one stimulus modality to another would be enhanced. If a difference in delays in the predicted direction did exist, then Davis contended the single channel concept of nonoverlapping central organization times would be strengthened.

A graphic representation of actual values for incurred delays of left hand reaction times is presented in Figure II. Support is apparently afforded Davis' theory concerning the nature of incurred delays. Delays for left hand to sound reaction times were consistently longer than delays for left hand to light reaction times. These differences in actual delays were fairly consistent from intervals 50 to 200 msec. At interval 250 msec. the differences in delays began to diminish until at interval 500 msec. there was almost no difference. Table 4 summarizes the magnitude and limits of these delays and affords a comparison between the two groups in paired responses.

Thus, the possibility that the additional source of delay at short intervals is due to a time requirement of the central mechanisms to shift from one stimulus modality to another seems discounted on a criterion set up by Davis—the delays in the visual-auditory sequence were greater than in the auditory-visual sequence. Unless one argues that it is more difficult for the central mechanisms to shift from visual to auditory than from auditory to visual modalities, it must be concluded that the additional delay observed by Davis in second response reaction times at short intervals is not due to a time requirement of the central mechanisms to shift from one stimulus modality to another.

The evidence obtained appears to offer some support to Davis' contention that delays in second response reaction times are caused, in part at least, by the order in which stimuli occupy the central mechanisms and by the duration for which they occupy the central mechanisms. Thus, when the visual stimulus is presented first, with its inherently longer central organization time requirement, the second response is delayed more than if the initial stimulus was an auditory one. The analysis called for greater delays in second responses when the sequence was visual-auditory than when the sequence of stimulus presentation was auditory-visual. The general pattern of results substantiated this analysis.

TABLE 4.—PAIRED LEFT HAND REACTION TIMES, INCURRED DELAYS, STEP INCREASES, AND DIFFERENCES IN DELAYS FOR TWO EXPERIMENTAL GROUPS IN MILLISECONDS

Interval	Left Hand To Sound	Delay	Step Increase	Left Hand To Light	Delay	Step Increase	Diff. in Delays
50 ms	304.70	128.63	43.15	296.46	128.63	35.56	41.02
100 ms	261.55	126.50	26.16	260.90	93.07	32.23	33.43
150 ms	235.39	100.34	24.59	228.67	60.84	20.49	39.50
200 ms	210.80	75.75	21.27	208.18	40.35	11.49	35.40
250 ms	189.53	54.48	19.10	196.69	28.86	7.05	25.62
300 ms	170.43	35.38	11.37	189.64	21.81	4.24	13.57
350 ms	159.06	24.01	1.80	185.40	17.57	-0.58	6.44
400 ms	157.26	22.21	-2.89	185.98	18.15	-0.40	4.06
450 ms	160.15	25.10	-7.97	186.33	18.55	-13.58	6.55
500 ms	168.12	33.07		199.96	32.13		0.94

The fact that the magnitude of delays incurred by each of the two groups exhibits the relationship called for by Davis does not, however, constitute proof that the delays are totally due to the single channel concept forwarded by Davis. Poulton's (5) contention that delays are due to lack of a necessary foreperiod in which to prepare for a response has not been disenhanced by the results of the present investigation.

One might argue, for example, that if delays were due to lack of necessary foreperiod as contended by Poulton, and if the intervals of time between stimulus presentation could be taken to correspond to different lengths of foreperiods for second response members, then it would seem a reasonable expectation that for the same foreperiod (interval between stimulus presentation) lengths, delays in left hand reaction time for the two experimental groups would be the same. Under this premise, the fact that the magnitude of delays for left hand responses in paired responses is seemingly dependent upon the sequence of stimulus modality presentation would appear to be vitiating to Poulton's theory.

The fallacy in this analysis, however, would be the acceptance of intervals of time between stimulus presentation as being identical foreperiod lengths for second response members in each of the experimental groups. Poulton's analysis maintains that a response member must have an adequate foreperiod to build up a readiness to respond; furthermore, at least part of this readiness set cannot be built up until after the first response has been made. Thus, a foreperiod of adequate length, undisturbed by a response to a previous stimulus, is required for a second response to be made without the incurrence of a delay.

The present investigation did not fulfill these requirements since the initial response in each of the experimental groups was made to a different stimulus modality. For example, in the group visual-auditory, the longer central organization time requirement for the visual response served to shorten the undisturbed foreperiod length available for the second response member. Similarly, in group auditory-visual, the shorter central organization time requirement for the auditory response served to lengthen the undisturbed foreperiod length available for the second response member. Under these conditions, the difference in delays encountered in the present investigation might readily be explained by Poulton's theory of required and undisturbed foreperiod lengths just as efficiently as by Davis' single channel concept of nonoverlapping central organization times.

It should also be noted that Davis' analysis of sensory conduction time requirements called for a difference in the magnitude of delays to be about 60 msec. longer in the visual-auditory sequence than in the auditory-visual sequence of stimulus presentation. The obtained differences in delays as seen in Table 4 were fairly consistent over the intervals 50 to 200 msec. running 41.02, 33.43, 39.50, and 35.40 msec. Although the direction of the differences between incurred delays tended to support Davis' single channel concept, Davis' estimates of sensory conduction requirements were approximately 20 to 25 msec. too long to fit the present data.

But what is even more important, the finding of a correct relationship between delays still does not explain the cause of additional delays over and above Davis' predictions at the shorter intervals between stimulus presentation. The presence of this additional delay is revealed in Table 5. In each group, actual reaction times for second response members were much longer than predicted by Davis' formula. Davis was aware of a similar shortcoming in his own data when he considered the possibility that "there may exist a truly refractory period following central activity" (3). The suggestion of a truly refractory period, of course, was the first explanation offered for the delay in reaction time when Telford (7) likened the phenomenon to nerve refractoriness.

TABLE 5.—COMPARISON OF PAIRED LEFT HAND REACTION TIMES IN MIILLISECONDS PREDICTED BY DAVIS' FORMULA WITH ACTUAL VALUES OBTAINED

	Intervals				
	50	100	150	200	250
Predicted Left Hand To Sound	254.94	204.94	154.94	135.05	135.05
Actual Left Hand To Sound	304.70	261.55	235.39	210.80	189.53
Predicted Left Hand To Light	255.92	205.92	167.83	167.83	167.83
Actual Left Hand To Light	296.46	260.90	228.67	208.18	196.69

The results of this investigation are also somewhat uncomplementary to Davis' single channel theory when the point at which delays in second response reaction times appear is considered. Davis' theory calls for delays in second responses only when the interval between stimuli is less than the duration of the initial reaction time. Thus, in the visual-auditory sequence a sharp appearance of delays would be expected at approximately the interval of 200 msec., and in the same manner, a sharp appearance of delays for left hand to light reaction time in the auditory-visual sequence to occur at interval 150 msec.

As seen in Tables 4 and 5, however, the point at which (a) delays in second response reaction times were present, and (b) the magnitude of step increases in delays as the interval between stimulus presentation was reduced in both experimental groups, suggests incompatibility with Davis' theoretical predictions.

Incurred delays for left hand reaction times in group auditory-visual were present over the entire range of intervals instead of appearing initially at interval 150 msec. Discounting the 500 msec. interval in which an expectancy effect apparently intruded, there was a general delay of approximately 18 msec. in left hand reaction time over the intervals 450 to 350 msec. These responses were significantly different from the corresponding simple reaction time measure, but were not significantly different from each other. Significant additional delays, presumably due to Davis' concept of a single channel response system, start to appear at interval 200 msec., which is 50 msec. too soon to be compatible with Davis' formulations. Furthermore, the existence of delays over intervals 500 to 250 msec. is entirely unaccounted for by Davis' theory.

An inspection of incurred delays for left hand to sound in group visual-auditory indicates the results parallel the findings in group auditory-visual. Delays were present over the entire range of intervals instead of appearing initially at interval 200 msec. Discounting the 500 msec. interval, there was a general delay of approximately 22 to 25 msec. over intervals 450 to 350 msec. These responses were significantly different from the corresponding simple reaction time measure, but were not significantly different from each other.

As soon as the interval between stimuli was further decreased, however, additional delays started to appear, apparently superimposed over the general delay present at intervals 450 to 350 msec. The increase in delay from interval 350 to 300 msec. was not significant. From interval 250 msec. on, however, all increases in delays were significant; that is, as the interval between stimuli was reduced by 50 msec. steps from 300 to 50 msec., significant increases in left hand to sound reaction time occurred. Thus, significant delays started to appear at interval 250 msec., which is again 50 msec. too soon to be compatible with Davis' formulations. In addition, the presence of a general delay over intervals 500 to 300 msec. is similarly unaccounted for by Davis' theory.

Summary

In general, the results of this investigation supported previous reports citing delays in the second response member when the interval of time between stimulus presentation in a paired response situation was 0.5 seconds or less. Delays in second responses occurred regardless of the sequence of stimulus modality presentation. The fact that delays were incurred with both stimulus modality sequences and that incurred delays for left hand reaction times were greater in the visual-auditory sequence than in the auditory-visual sequence appears to offer some support to Davis' contention of a single channel concept of human response processes.

However, obvious discrepancies between the results and Davis' predictions were reflected in the separate trend test analyses for each experimental group. The data suggested a source of additional delay in second response

reaction times which could not be accounted for. As a result, the separate trend test analyses jointly adduced the inadequacy of Davis' postulates as a description of either the magnitude or the limits of incurred delays in second response reaction times over crucial intervals of time between stimulus presentation.

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Response to a Cold Pressor Test during Physical Training[1]

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Abstract

Members of the 1958-59 varsity basketball team at Santa Barbara and a control group of physical education majors not in training were tested each three weeks during a 17-week season of basketball competition on their response to a step test and to a cold pressor test. The results indicated that significant step test recovery pulse rate changes were made by the basketball players after three weeks of training. Maximum changes were found to occur after 17 weeks of training. The diastolic pressure response to the cold pressor test increased significantly (7 mmHg.) after six weeks of training and this was maintained for 17 weeks. The results indicated that a possible increased sensitivity or tone of the peripheral vessels resulted from physical training.

RECENT EXPERIMENTS have indicated that daily physical conditioning results in certain peripheral vascular changes in man. This suggests that conditioning may bring about a more sensitive response to stress (4, 6). The present study was carried out to investigate the possibility that physical training for athletic competition results in an adjustment of the autonomic nervous system to stress other than exercise. A cold pressor test reported by Hines (2) was used as the test of stress, and the changes in physical conditioning were estimated with a one-minute step test reported previously (5). The pressor test reflects the vascular reactivity to pain.

Methods

The subjects in the experiment were 14 members of the 1958-59 Santa Barbara varsity basketball team and 10 control subjects who were physical education majors not participating in athletics. Tests were given each three to four weeks during the time when the experimental group was working out daily for one to one and one-half hours. The experiment began in October and ended in February, 17 weeks later.

The two groups were not matched before the experiment due to the difficulty of obtaining a group similar to a varsity team. There was, however, a check on the testing procedure used in following the changes in the control group. Both groups were tested between 2:00 p.m. and 4:00 p.m. at least two hours from a meal. The subjects were seated in a chair until the pulse rate and blood pressure measurements had leveled off (10–15 min.). The

[1] This study was supported by faculty research funds and research funds from Wood Glen Hall in Santa Barbara, California.

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subjects then placed the right hand to above the wrist in 4° C water. The blood pressure was estimated from the left arm by the ausculatory method with a mercury sphygmomanometer. The systolic and diastolic pressures (fourth phase) were recorded before and each 30 sec. during 60 sec. immersion and 90 sec. recovery. Following the cold pressor test, the subjects stepped up and down for one minute on a 17 in. bench at the rate of 36 steps per minute. The sitting pulse rate was counted before, immediately after the effort, and each minute during 3 min. of recovery. The 15 sec. pulse count, taken from the radial artery, was multiplied by four to convert the figure to rate per minute. The subjects were tested several times before beginning the experiment in order to adjust to the procedure.

Results

Changes beyond the .05 level were considered significant, using paired t ratios. The resting and immediately after exercise pulse rates of the experimental group decreased significantly after 17 weeks of training. The pulse counts obtained at 1, 2, and 3 min. after exercise decreased significantly after three weeks of training. The pulse rates of the control group did not change significantly during the experiment (Tables 1 and 2). Before the physical training began in October, the average pulse rate following exercise had not recovered in either group within 3 min. In the experimental group after three weeks of training, the average pulse count had returned to the resting level within 2 min. The sum of the pulse rates per minute of the experimental group, taken at 1, 2, and 3 min. after exercise, lowered significantly (.01 level) from 221 ± 4.6 in October to 173 ± 5.8 in February. These results parallel those reported previously (5).

TABLE 1.—MEAN PULSE RATE/MINUTE FOLLOWING ONE-MINUTE STEP TEST DURING CONDITIONING FOR BASKETBALL

Week of Training	Resting Mean $\sigma\mu$	Post Exercise Mean $\sigma\mu$	1-Minute Recovery Mean $\sigma\mu$	2-Minute Recovery Mean $\sigma\mu$	3-Minute Recovery Mean $\sigma\mu$
		Experimental Group (N–14)			
Test I					
Pretraining	67 ± 2.6	132 ± 3.9	80 ± 4.1	71 ± 3.3	71 ± 3.0
Week 3	65 ± 2.9	130 ± 2.1	71 ± 2.8	62 ± 2.2	64 ± 3.0
Week 6	63 ± 2.6	132 ± 3.2	68 ± 3.5	62 ± 3.1	63 ± 2.8
Week 9	60 ± 2.1	126 ± 3.9	71 ± 3.3	60 ± 2.7	62 ± 2.5
Week 13	67 ± 3.1	127 ± 3.1	70 ± 4.3	64 ± 3.4	65 ± 3.0
Week 17	59 ± 3.5	121 ± 4.6	60 ± 3.8	56 ± 3.7	57 ± 3.5
		Control Group (N–10)			
Week 1	70 ± 3.1	135 ± 4.0	86 ± 4.6	79 ± 4.6	75 ± 4.3
Week 3	66 ± 3.6	133 ± 4.9	89 ± 5.9	78 ± 5.5	73 ± 4.7
Week 6	64 ± 2.8	135 ± 4.5	89 ± 6.7	78 ± 5.2	73 ± 4.1
Week 9	69 ± 2.5	132 ± 4.1	82 ± 3.3	73 ± 3.1	71 ± 2.1
Week 13	66 ± 2.3	134 ± 3.2	86 ± 5.2	77 ± 3.7	73 ± 2.8
Week 17	67 ± 1.9	133 ± 2.8	86 ± 4.1	77 ± 2.8	72 ± 2.5

The results of the cold pressor test did not change significantly in the control group (Tables 3, 4, and 5). In the experimental group, the systolic pressure responses to the cold pressor test did not change significantly (Table 5). The diastolic pressure responses on the other hand, were significantly greater after six weeks training and this was maintained until the end of training (Table 5).

The blood pressure measurements recovered from cold pressor test within 90 sec. during the experiment. There were no changes in the time necessary for the blood pressures to return to the control level.

TABLE 2.—MEAN PULSE RATE DIFFERENCES AFTER STEP TEST BETWEEN PRETRAINING TEST AND TESTS DURING PHYSICAL TRAINING

Week of Training	Resting	Post Exercise	1-Minute Recovery	2-Minute Recovery	3-Minute Recovery
Experimental Group (N–14)					
3 Weeks	−2.3	− 1.6	− 9.2[a]	− 9.1[b]	− 6.6[a]
6 Weeks	−3.8	0.3	−11.7[b]	− 7.6[b]	− 7.2[a]
9 Weeks	−7.2[a]	− 5.8	− 9.2[a]	−10.6[b]	− 8.5[b]
13 Weeks	0.1	− 4.7	−10.0[a]	− 6.6[a]	− 5.9[a]
17 Weeks	−8.1[b]	−10.8[a]	−19.6[b]	−14.9[b]	−13.8[b]
Control Group (N–10)					
3 Weeks	−3.3	− 1.7	3.1	− 0.2	− 2.1
6 Weeks	−5.4	0.1	3.1	− 0.4	− 2.0
9 Weeks	−0.1	− 3.2	− 3.7	− 5.6	− 4.1[a]
13 Weeks	−4.2	0.7	0.0	− 7.8[a]	− 8.1
17 Weeks	−2.5	− 2.0	0.6	− 1.4	− 2.9

[a]Difference significant beyond the 5 percent level.
[b]Difference significant beyond the 1 percent level.

TABLE 3.—MEAN SYSTOLIC BLOOD PRESSURE MEASUREMENTS OF THE COLD PRESSOR TEST DURING PHYSICAL TRAINING

Week of Training	Before Immersion Mean σ_μ	30-Second Immersion Mean σ_μ	60-Second Immersion Mean σ_μ	30-Second Recovery Mean σ_μ	60-Second Recovery Mean σ_μ	90-Second Recovery Mean σ_μ
Experimental Group (N–14)						
Pretraining	116 ± 2.7	126 ± 3.2	127 ± 3.3	120 ± 2.7	118 ± 2.3	116 ± 2.3
3 Weeks	117 ± 2.8	128 ± 3.4	131 ± 3.8	122 ± 3.2	118 ± 3.2	118 ± 3.1
6 Weeks	119 ± 2.5	128 ± 3.3	132 ± 3.4	124 ± 2.9	120 ± 2.4	119 ± 2.5
9 Weeks	113 ± 2.6	118 ± 3.9	126 ± 4.1	119 ± 3.6	115 ± 2.9	113 ± 2.1
13 Weeks	114 ± 2.2	123 ± 3.2	130 ± 3.0	117 ± 2.7	115 ± 2.4	113 ± 2.3
17 Weeks	111 ± 2.3	121 ± 3.1	125 ± 3.1	117 ± 3.1	113 ± 2.5	112 ± 2.2
Control Group (N–10)						
Pretraining	113 ± 2.9	120 ± 2.9	128 ± 4.2	124 ± 1.3	118 ± 2.7	114 ± 2.7
3 Weeks	114 ± 3.0	121 ± 2.6	130 ± 3.2	123 ± 1.2	118 ± 2.3	113 ± 2.3
6 Weeks	113 ± 3.7	124 ± 5.2	132 ± 4.8	123 ± 4.3	117 ± 2.4	114 ± 2.7
9 Weeks	115 ± 3.7	121 ± 3.9	129 ± 4.5	123 ± 6.6	117 ± 5.4	115 ± 4.5
12 Weeks	112 ± 2.1	122 ± 3.4	130 ± 3.8	120 ± 4.6	113 ± 3.2	113 ± 3.2

TABLE 4.—MEAN DIASTOLIC BLOOD PRESSURE MEASUREMENTS OF THE COLD PRESSOR TEST DURING PHYSICAL TRAINING

Week of Training	Before Immersion Mean σ_μ	30-Second Immersion Mean σ_μ	60-Second Immersion Mean σ_μ	30-Second Recovery Mean σ_μ	60-Second Recovery Mean σ_μ	90-Second Recovery Mean σ_μ
Experimental Group (N–14)						
Pretraining	72 ± 1.6	80 ± 2.3	82 ± 2.5	77 ± 1.9	74 ± 1.8	72 ± 1.5
3 Weeks	74 ± 1.6	85 ± 1.5	87 ± 1.8	75 ± 1.5	75 ± 1.5	75 ± 1.4
6 Weeks	74 ± 1.2	87 ± 2.1	91 ± 2.6	77 ± 2.0	75 ± 1.4	75 ± 1.2
9 Weeks	70 ± 2.2	82 ± 2.3	85 ± 2.4	74 ± 2.1	71 ± 2.2	70 ± 2.1
13 Weeks	73 ± 2.5	84 ± 2.6	90 ± 2.4	76 ± 2.3	73 ± 1.9	73 ± 2.0
17 Weeks	71 ± 2.1	84 ± 2.2	86 ± 2.2	72 ± 2.0	72 ± 2.1	71 ± 1.8
Control Group (N–10)						
Pretraining	73 ± 2.1	83 ± 2.5	89 ± 3.9	78 ± 3.4	75 ± 2.2	74 ± 1.9
3 Weeks	72 ± 2.8	82 ± 2.8	90 ± 1.8	74 ± 2.3	71 ± 2.0	72 ± 1.8
6 Weeks	70 ± 4.1	87 ± 5.1	89 ± 3.8	76 ± 2.8	76 ± 2.5	73 ± 2.3
9 Weeks	72 ± 3.3	87 ± 3.5	90 ± 3.0	78 ± 3.9	76 ± 2.1	72 ± 1.7
12 Weeks	70 ± 2.5	83 ± 2.9	90 ± 3.2	77 ± 2.4	73 ± 3.0	73 ± 2.6

TABLE 5.—MEAN BLOOD PRESSURE INCREASES FOLLOWING COLD PRESSOR TEST DURING CONDITIONING FOR BASKETBALL (mmHg)

Week of Training	60-Second Increase		Change from Test I	
	SBP	DBP	SBP	DBP
Experimental Group (N = 14)				
Pretraining Test I	11 ± 2.6	10 ± 2.0	-----	-----
3 Weeks	14 ± 2.5	13 ± 2.2	+ 3	+ 3
6 Weeks	13 ± 2.3	17 ± 1.4	+ 2	+ 7[a]
9 Weeks	13 ± 2.0	15 ± 2.5	+ 2	+ 5[a]
13 Weeks	16 ± 2.8	17 ± 2.6	+ 5	+ 7[b]
17 Weeks	14 ± 2.7	15 ± 1.8	+ 3	+ 5[a]
Control Group (N = 10)				
Pretraining Test I	15 ± 3.0	16 ± 2.6	-----	-----
3 Weeks	16 ± 2.4	18 ± 3.1	+ 1	+ 2
6 Weeks	19 ± 3.2	19 ± 2.6	+ 4	+ 3
9 Weeks	14 ± 2.0	18 ± 2.8	− 1	+ 2
12 Weeks	16 ± 2.3	20 ± 2.9	+ 1	+ 4

[a]Difference significant beyond the 5 percent level.
[b]Difference significant beyond the 1 percent level.

Discussion

The average pulse rate measurements taken at 1, 2, and 3 min. following the step test changed in exactly the same manner as in the 1957-58 study (5) and that reported by Montoye (7). This parallel change indicates, as have other studies at Santa Barbara, that three to six weeks of hard training result in significant circulatory changes. Since the 1957 team had a training break between the tenth and thirteenth weeks of training, it was decided that in 1958 the team would continue to work lightly during these weeks and

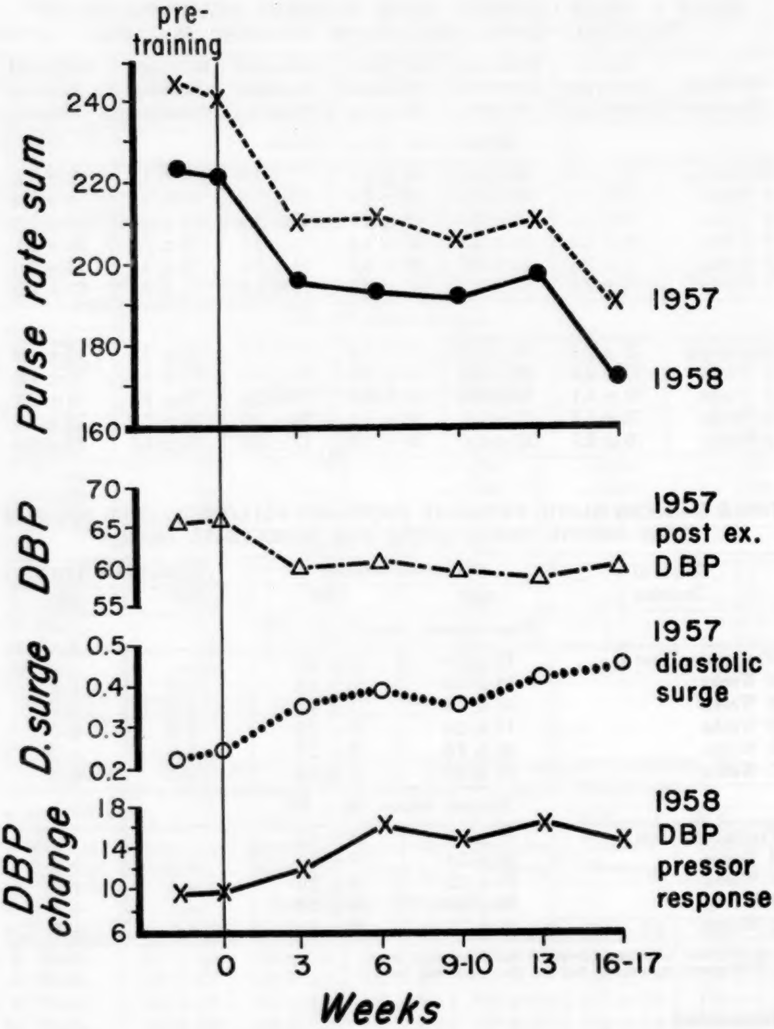

FIGURE I. Measurements taken on the 1957 and the 1958 basketball teams that changed significantly during training. The upper 2 lines show the results of the step test given during training. The sum of the 1, 2, and 3 minute recovery pulse rates are shown. The third and fourth lines represent the 1957 data showing the changes that occurred in the diastolic part of the pulse wave and the diastolic blood pressure taken immediately after the step test. The bottom line shows the change in the diastolic blood pressure response to the cold pressor test.

perhaps the recovery curves would be different. The results, however, show a similar exercise recovery curve, regardless of whether there were or were not workouts between the ninth and thirteenth weeks.

After the first six weeks of conditioning, the average sum of the 1, 2, and 3 min. pulse counts following the step test leveled off as in the 1957-58 study, then lowered to a maximum point between 13 and 17 weeks of training. After three weeks of training, the average pulse rate dropped below the control level 2 min. following the step test. This same phenomenon occurred in the 1957-58 study after 16 weeks of training and is a common occurrence. The average resting pulse rate decreased significantly after nine weeks of training in the present study, but this did not occur in 1957. It is possible that the subjects in the present experiment were more relaxed before the step tests or that the cold pressor test resulted in the resting pulse rate becoming more nearly basal.

The pulse rates were slightly lower throughout the present experiment, but there was an average increase of 65 beats/minute following exercise, regardless of training, as was seen previously.

The average control systolic pressure measurements did not decrease significantly as with the 1957-58 study. In other studies at Santa Barbara, we usually have found that resting blood pressure measurements decrease with training if the workouts are strenuous enough.

The increased diastolic pressure response to the cold pressor test in the present study indicates a change in the vascular system similar to that shown by the brachial pulse wave and the postexercise diastolic pressure measurements taken during training (6). The size of the diastolic wave increased during training in 1957 and the postexercise diastolic pressure decreased, reflecting an increased tone or sensitivity of the peripheral vessels.

MacCanon (3) recently reported the effects of oxygen inhalation on the increased response of the diastolic pressure to the cold pressor test (7 mmHg). Physical training resulted in approximately the same changes in the present study (see Table 5). MacCanon suggested that vasomotor components might be responsible for the effects of oxygen on the pressor responses. The increased transport of oxygen during exercise may be the stimulus to the changes found in the present study.

Studies are needed to determine more specifically how physical training sensitizes peripheral body structures and how the emotional response to pain affects the vasomotor reflexes. There is not enough evidence at present to do more than postulate the specific changes that occur with physical training or give meaning to the implications.

Summary and Conclusions

The results of a step test and the response to a cold pressor pain test were noted during a physical training period of 17 weeks. The experimental subjects were 14 members of a varsity basketball team. It was found that the experimental subjects made significant changes with respect to the step test recovery pulse rate within three weeks. The blood pressure responses to the

cold pressor test remained within normal limits during training (10-20 mmHg). However, the diastolic pressure response increased significantly from 10 to 17 mmHg pressure. The systolic pressure response was not affected by training.

The results indicated that the physical conditioning affected the local vascular response to pain.

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Effect of a Single Day's Swimming on Selected Components of Athletic Performance[1]

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Abstract

The purpose of this investigation was to study the effect of swimming on selected components of athletic performance as measured by the following tests: back strength, leg strength, bicycle ergometer (combination of strength and endurance, but predominantly endurance), and vertical jump (explosive power). Subjects were pretested for three days on each test, after which they participated in 45 minutes of swimming, and performance was tested on one test one hour after the swim on any given day. A single day's swimming was found to significantly affect the vertical jump, but other performance tests were not affected.

MANY COACHES AND PHYSICAL educators show real concern when swimming is mentioned along with competition in another sport. A few coaches have allowed an occasional swim for a short period of time, but most have objected to a large amount of endurance swimming. Reasons for anxiety seem to be focused on the traditional belief that swimming tends to soften, lengthen, and stretch muscles so that they are ineffective in the performance of any skill involving explosive power. Others indicate that swimming movements interfere with the learning of various sports skills. At any rate, there is reluctance on the part of coaches and athletes to allow swimming during another competitive sport season.

The author first attempted to approach this problem on a scientific basis when a study was completed on the effect of swimming on the learning of selected gross motor skills (1). Two skills, volleyball tap for accuracy and three flights of high hurdles timed by an electric timing device, were selected for study. The skills were learned on alternate days from the swimming performance. Two different scoring systems were used, but no significant difference was found between the control and experimental groups. Swimming did not interfere with learning the selected skills.

Whitaker (4) used the same skills but had his experimental group swim two hours preceding the learning sessions on the selected skills. He also found that swimming did not interfere with the learning of the selected sports skills when swimming and performance were on the same day. This led to the question of whether swimming affected such basic components

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[1] This study was supported by Utah State University Research Funds.

as speed and reaction time, strength, explosive power, and short duration strength and endurance, and whether one was affected more than another.

Statement of the Problem

The purpose of this investigation was to study the effect of swimming on selected components of athletic performance. Although the basic ingredients of performance cannot be isolated in all cases, it is postulated that such components as speed and reaction time, strength, endurance, and explosive power are important. Tests were selected which appear to have a predominance of these qualities.

Subjects

Subjects were 16 Utah State University physical education majors representing varieties of human physique and athletic ability. On the basis of empirical evidence resulting from having these people in activity classes, all were judged to be in excellent physical condition.

Procedure

Each subject was pretested for three days on all tests for the purpose of learning and conditioning and to form a base of scores for checking his performance on the subsequent swimming days. Only one test was administered on any given day so that one test would not have an effect on another. In addition, the sequence of performing the tests was counterbalanced so that each test was arranged in four different groups of sequences (Table 1).

Swimming periods were 45 minutes of supervised activity, which consisted of playing water basketball continuously and active endurance swimming

TABLE 1.—EXPERIMENTAL DESIGN
(4 x 4 Latin Square)

I				II			
T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
A	B	C	D	A	B	C	D
B	A	D	C	B	C	D	A
C	D	B	A	C	D	A	B
D	C	A	B	D	A	B	C

III				IV			
T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
A	B	C	D	A	B	C	D
B	D	A	C	B	A	D	C
C	A	D	B	C	D	A	B
D	C	B	A	D	C	B	A

Key
T_1—Back and leg strength test
T_2—Speed and Reaction time test
T_3—Bicycle ergometer (endurance)
T_4—Vertical Jump (explosive power)
ABCD—Subjects (total of sixteen)

for the last five minutes. All subjects were actively engaged in the water during the entire period. Following each day's swim, subjects rested for one hour, after which they were tested on one test only.

Tests

The gross motor tests were selected to test such basic components as speed and reaction time, strength, power, and endurance. These items are believed to be an important part of athletic performance, and the tests have indicated high precision on another study (2). The tests were given at the same time each day.

Test 1. Starting and Running

An upright starting position was used with each subject running ten yards. The electric timing device was started by clapping two copper covered boards together. As the sheets of copper came together the clock started and continued until the runner broke the electric circuit by striking a gate switch, waist high, across the finish line. Time was recorded to the nearest 1/100 sec. Each subject's daily score included the average of five timed trials.

Test 2. Vertical Jump

The subject reached as far as possible with heels kept on the floor and made a chalk mark on the wall. He next executed three jumps from a crouched position, making a finger imprint each time on the wall board. The distance from the top of the reach mark to the top of each pump mark was measured. The best of three jumps was used as the daily score.

Test 3. Bicycle Ergometer

Maximum revolutions in 60 sec. against a 10-lb. resistance were used as the daily score.

Test 4. Back and Leg Strength

A DS-2BL back and leg strength dynamometer manufactured by the Ann Arbor Instrument Works was used in the experiment. Standard back and leg strength testing procedure (as outlined by H. Harrison Clarke) was used throughout the study.

Results

Each subject was tested on the skill tests for three separate days on each test prior to being tested on the swimming days. The mean of these three preliminary testing days was used as a control score on each skill test. The change from the control score and the swimming day's test score for each subject was listed for each subject for each test, and the accumulated changes were used for analysis on each skill test.

The data for each skill test were treated with the t test to check the significance of the difference between the control scores and the swimming day scores.

Mean differences from swimming day scores and control day and statistical evaluation are presented for each skill test in Table 2. The only test found

TABLE 2.—MEAN DIFFERENCE FROM CONTROL DAY'S TESTS AND STATISTICAL EVALUATION FOR THE FIVE SKILL TESTS

Skill Test	Mean Difference from Control Scores	Standard Error of Difference	t
Back Strength (lbs.)	+10.5	9.59	1.09 (N.S.)
Leg Strength (lbs.)	+25.1	39.92	.63 (N.S.)
Starting and Running (1/100 sec.)	+ .0181 (decrease in time)	.00936	1.94 (.10)
Bicycle Ergometer (revolutions)	+ 1.56	2.297	.68 (N.S.)
Vertical Jump (inches)	− 1.25	.244	5.14 (.01)

to be significantly affected by swimming was the vertical jump, which was significant at the 1 percent level of confidence. The speed and reaction test, although not significant, did show significance at the 10 percent level. This is mentioned only because the test seems to have some of the explosive qualities contained in the vertical jump test. A single day of swimming was not found to have any effect on the back strength, leg strength, and bicycle ergometer.

Discussion

It has been pointed out that swimming was not found to have any effect on learning selected gross motor skills when swimming was performed on alternate days (1), or when swimming was within two hours of the learning tests (4). The present investigation, in addition, showed no significant effect on pure back strength, leg strength, and what is believed to be strength and endurance as measured by an all-out ride on the bicycle ergometer for 60 sec. No significant effect was found on speed and reaction time as measured by starting and running 10 yds., although significance was indicated at the 10 percent level of confidence.

Swimming was found to have a significant negative effect on explosive power as measured by the vertical jump. This is consistent with findings in other research conducted in our laboratory (3). Whenever subjects have had large amounts of activity, even as much as two or three days prior to testing, a significant negative effect on a person's ability to jump has been shown. It appears that the prior activity does not necessarily need to be of any particular kind. The effect seems to be related to activity per se rather than a selected form of activity in or out of water.

The ability of the body to exert energy in a short period of time (explosive power) seems to be negatively affected more than other components of performance. It is postulated that the significance at the 10 percent level of confidence in the speed and reaction test might have some relationship to the presence of this factor. There seems to be some explosive quality necessary in the start of a run which may have been affected by the swimming.

Another empirical observation that seems important was that a number of subjects, after the swimming, did not appear to achieve their initial burst of all-out speed previously obtained in the pretests for the 60 sec. bicycle ergometer ride; yet their total number of revolutions, which appears to reflect endurance, was not affected significantly.

It should be mentioned that the swimming situation in this experiment is only one of many situations which could involve varying amounts of swimming. The extent of swimming on any given day for this study was fairly long and intense. When the length and intensity is reduced, as it often is when used in conjunction with athletics, one might not find a significant negative effect on these components of performance.

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A Cinematographic and Mechanical Analysis of the External Movements Involved in Hitting a Baseball Effectively[1]

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Abstract

A controlled, cinematographic study was made of 17 proficient, professional hitters of the Eastern League hitting a baseball effectively, in order to make a qualitative and quantitative analysis of the mechanics of hitting. Angular measurements of the forward-swing bat delineated a sharply increasing rate of velocity as the bat approached the baseball. Responsibility for the generation of the force imparted to the bat was made manifest by the far greater velocity of the hands-and-wrists over the hips, and, similarly, of the hips over the striding foot. Additional analyses were made of the efforts to maintain bodily balance, the judgment time of each hitter, the changing levels of the head, the preparatory movements of the stance, and the extent of arm movement before the follow-through.

DURING THE COURSE of the 1959 baseball season, a 16mm movie camera was utilized to film professional players of the Class A Eastern League while active in batting practice preceding regularly scheduled games at Pynchon Park, the playing field of the Springfield Giants in Springfield, Massachusetts. The filming was done in slow motion from a position about 15 feet directly in front of the anterior side of each hitter while in his batting stance.

The aim of this cinematographic study was to scrutinize the mechanics of hitting a baseball effectively through qualitative and quantitative analyses that were guided by previously prepared standards and limitations and effected through intensive work on the films as viewed through a 16mm motion picture editor.

Qualitative Nature of Study

Seventeen proficient, professional hitters were filmed and analyzed in the full sequence of their active and preparatory movements involved in hitting a baseball effectively. The following requirements guided the selection of the hitters: (a) a minimum batting average of .275 for over 220 times at bat; and/or (b) superior skills shown through other statistics of hitting. Only three of the hitters in this study failed to bat at least .275. Each of these three hitters compiled over 100 base hits. One had 200 total bases; another had 15 home runs.

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[1] This research was conducted as part of the preparation for the master's degree at Springfield College, Springfield, Massachusetts.

The mean batting average for the selected 17 hitters was .297; the mean batting average for the entire league was .267. The mean slugging average of this study's hitters was .446; the average for the entire league was .404. Three of this study's hitters were qualifiers for the individual batting championship. Three rated among the first ten in the league in runs batted in. Two were in the first ten in home runs. Three were in the first ten in total bases. Three were in the first ten in the total number of base hits.

Each hitter was analyzed only in the portions of the films showing the movements involved in *effective* hitting. That is, each was analyzed hitting a baseball for a very considerable distance (against the fence or in excess of 370 ft.) or very sharply with a relatively flat trajectory (line drives) that carried the ball beyond the limits of the infielders in their normal positions.

The emphasis of the mechanical analysis was on the phases of the batting movements commencing with the initial forward, linear, or rotary movements toward the path of the baseball and terminating at the instant the hitter's bat contacted the baseball.[2] Generally, little concentration was focused on the preparatory efforts of the stance or the post-hitting movements of the follow-through.

Bases for the Qualitative Analyses

CALIBRATION OF THE CAMERA

The camera was calibrated so that the speed of any selected bodily movement could readily be obtained by counting the number of movie frames needed to film it. First, the eight-foot fall of a heavy, iron weight was filmed in slow motion. Subsequent computations were based on the formula for the law of falling bodies which states that the distance traveled is equal to one-half the standard value of the acceleration of gravity (32.2 ft/sec.^{2}) multiplied by the time in seconds squared ($S = \frac{1}{2}gt^2$). The computed time of the eight-foot fall was 0.7049 seconds. Since the camera used 35 frames to film the full fall of this iron weight, each movie frame was calculated to consume 0.02014 seconds. The camera was kept fully wound throughout the study to minimize the effects of reduced tension in the spring.

CORRECTION FACTORS

Correction factors are necessary for reliable and valid measurements of linear distance on films. At the time of the filming, the writer believed that the known length of home plate would readily permit computation of correction factors, but after the completion of the filming, it was realized that the object of known length on the film must be the same distance from the camera as the object to be measured if accurate results are to be derived. Since the home plate was no longer applicable as the known object, the writer arbitrarily assumed that the length of each hitter's bat was 35 in. even though neither the labeled nor the precise length of each bat was definitely

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[2] Since it was not possible to detect the bat actually contacting the baseball during hitting as filmed by the 16mm movie camera in slow motion, the writer arbitrarily selected the movie frame that showed the bat from a position parallel with the front line of the home plate to about six inches forward toward the pitcher. Whenever the phrase "contact with the baseball" is used in this article, it is used in this sense.

known, and computed the correction factors from this basis. Repeated measurements of the bat of each hitter in the position of the follow through, wherein the bat was pointed at the pitcher, enabled the writer to obtain satisfactory film lengths that were then divided into the known length (35 in.) of the bat for the desired correction factors. Practical applications and comparisons of the heights of hitters in their stances to similar objects such as the bars on the batting cage or to each other showed these correction factors to be quite accurate.

Measurements Based on Timed Movements

VELOCITY OF BAT AND RELATIVE FORCE

The positions of the bat at the moment of contact with the baseball and in the three preceding movie frames were traced on pieces of white paper attached securely to the screen of a 16mm editor after each movie frame had been identically centered. These lines were extended to intersect, and thus three angles of 0.02014 sec. duration were formed: (a) the first angle formed by the lines representing the bat at contact with the baseball and at 0.02014 sec. before this contact, (b) the second angle formed by the lines representing the bat at 0.02014 sec. and at 0.04028 sec. before contact with the baseball, and (c) the third angle formed by the lines representing the bat at 0.04028 sec. and at 0.06042 sec. before contact with the baseball.

According to Newton's second law of motion the time rate of change of a body acted upon by an unbalanced force is proportional to the net force acting upon the body, and that body will move in the direction of the force. In terms of a formula, force is equal to the product of mass multiplied by velocity divided by the time interval $(F = (m\ v)/t)$. The bat, representing mass, was constant for each hitter. The time of each movie frame was 0.02014 sec. Therefore, the time interval was constant for each of these measured angles. Thus, it may be concluded that the force generated for hitting increased at the same rate as the measured increases in velocity.

The measurements of the degrees of movement per 0.02014 sec. for 15 of this study's hitters showed a steadily increasing number of degrees in each angle as approach was made to the point of contact between the bat and the baseball. Sixteen hitters moved their bats 40 percent or better of the total degrees of the three angles in the first angle or time interval. Thirteen moved their bats 50 percent or better in the first angle. Six hitters moved their bats 60 percent or better in the last 0.02014 sec.

The mean percentages of movement of the bat for the 17 hitters for each of the three measured angles was: (a) first angle, 57.0 percent, (b) second angle, 28.9 percent, and (c) third angle, 14.1 percent. Table 1 presents the measurements of these angles for each of the 17 hitters.

RELATIVE VELOCITIES OF MAJOR BODILY SEGMENTS

The previous section raises a question about the pattern in which the force imparted to the bat is generated. Therefore, measurements of the length of the stride and computations of the arcs of the hip and hands and wrists rotations were prepared in conjunction with a determination through film

analyses of the times of these respective displacements in order to calculate the relative velocities of these movements. In accordance with the principles outlined by Bunn (1), each successive member of the body should move faster than its predecessor in the chosen direction if the optimum speed is to be obtained.

All of the measurements, computations, and times were based solely on the most vital stage of hitting, i.e., they were limited to the effective, forward movements that brought the bat toward the path of the baseball, and in no case went beyond the point of contact between the bat and the baseball. The stride was determined as the difference between the distances of the forward foot from the rear foot in the batter's stance and in the position wherein contact was made between the bat and the baseball. The hip rotation was computed by measuring the width of the hips at the belt line in the movie frame after the stride and before the pivot, multiplying this figure by pi (3.1416), and then dividing the product by four (one quarter of a circle). The radius of the hands and wrists was determined by drawing a line between the midpoints of the batter's feet and waistline in the same movie frame before the pivot and then drawing a line from the hands and wrists perpendicular to the first line. Then, the computations followed the method employed for hip rotation. In order to account for possible deviations from an exact 90° arc, similar computations for the hips and hands and wrists were made at 80°, 85°, 95°, and 100°.

TABLE 1.—RELATIVE MOVEMENTS OF THE BAT PRIOR TO CONTACT WITH THE BALL

Player	First Angle		Second Angle		Third Angle	
	Degrees	Percent	Degrees	Percent	Degrees	Percent
M. Alou	71	86.5	8	9.8	3	3.7
A. Asaro	77	53.8	31	21.7	35	24.5
D. Bennetch	73	68.0	19	18.0	15	14.0
W. Carr	50	43.5	47	40.8	18	15.7
D. Davis	59	60.2	21	21.4	18	18.4
J. Davis	74	53.6	33	23.9	31	22.5
R. Farley	29	23.6	76	61.8	18	14.6
T. Haller	88	60.7	47	32.4	10	6.9
C. Horn	69	64.0	27	25.0	12	11.0
W. Kern	69	58.0	29	24.0	21	18.0
D. Mann	90	77.5	18	15.5	8	7.0
M. Mota	90	70.9	26	20.5	11	8.7
F. Reveira	59	60.0	30	31.0	9	9.0
W. Spiers	69	48.6	59	41.6	14	9.8
L. Stubing	72	54.0	42	31.0	20	15.0
L. Thomas	64	49.6	42	32.6	23	17.8
G. Valentin	65	52.0	38	30.0	23	18.0
Totals	1168		593		289	
Mean Averages		57.0		28.9		14.1

Based on a 90° arc, the computations showed that the hands and wrists traveled fastest for 15 of the 17 hitters. Based on an 80° arc for the hips and a 90° arc for the hands and wrists, the latter were fastest in each case. Based on an 80° arc for the hip rotation and a 100° arc for the hands and wrists rotation, the hands and wrists were also employed in the fastest manner by each hitter. In every instance, the movement of the foot in the stride was slowest.

The mean averages of the velocities of the selected bodily segments for the 17 hitters were as follows: (a) the hands and wrists (90° arc), 192.7 in./sec; (b) the hips (90° arc), 95.3 in./sec; and (c) the striding foot, 35.2 in./sec. Computations of the velocities of the selected bodily movements for each hitter are found in Table 2.

TABLE 2.—VELOCITIES OF SELECTED BODILY MEMBERS
(in inches per second)

Player	Velocity of Stride	Rotary Hip Motion			Hands-and-Wrists Motion		
		Velocities at Arcs of:			Velocities at Arcs of:		
		80°	90°	100°	80°	90°	100°
M. Alou	81.7	83.8	95.2	106.7	201.3	228.8	256.2
A. Asaro	18.8	60.8	69.1	77.4	145.1	164.9	184.7
D. Bennetch	26.0	73.0	82.9	92.9	174.3	198.1	221.9
W. Carr	29.8	66.4	75.4	84.4	181.4	206.2	230.9
D. Davis	14.3	172.8	196.4	219.9	163.4	185.6	207.9
J. Davis	19.7	90.7	103.1	115.5	181.4	206.6	230.1
R. Farley	27.1	54.8	62.2	69.7	120.7	137.1	153.6
T. Haller	43.6	63.8	72.6	81.3	178.0	202.2	226.5
C. Horn	48.5	71.4	81.2	90.9	201.3	228.8	256.2
W. Kern	48.6	58.4	66.4	74.4	237.3	269.7	302.0
D. Mann	29.8	70.7	80.3	89.9	153.6	174.5	195.5
M. Mota	25.4	95.8	108.8	121.9	99.2	112.8	126.3
F. Reveira	26.7	167.6	190.5	213.3	161.0	183.0	205.0
W. Spiers	58.2	67.0	76.2	85.3	193.5	219.9	246.3
L. Stubing	29.8	82.9	94.2	105.6	174.3	198.1	221.9
L. Thomas	47.5	81.3	92.4	103.5	120.2	136.6	153.0
G. Valentin	23.4	64.3	73.0	81.8	196.7	223.5	250.4
Mean Averages	35.2	83.9	95.3	106.7	169.6	192.7	215.8

DISTANCE OF THE BALL FROM HOME PLATE WHEN THE SWING BEGINS

How long can the batter wait before swinging? Scott (2) found that overhand, fast balls were pitched at speeds that ranged between 0.43 and 0.58 seconds. Relying on these findings, an answer was prepared for the above question by determining in feet per second the speeds of fast balls thrown at the ranges of Scott's study, measuring the times of the effective, forward movements of the hands and wrists for each of the 17 hitters, and then calculating the distance that the baseball would be from the home plate before the beginning of the swing.

The major limitation of these computations is that the given pitches of the filmed hitting sessions were not measured. The chief value is that they are based on the hitter's habitual batting movements and techniques and show that the baseball can travel a considerable portion of the distance between the pitcher's mound and the home plate because the hitter reacts to the pitch by striding while simultaneously judging the pitch.

The findings show that the pitched baseball was a mean distance of from 20.3 to 27.4 feet from the home plate for the 17 hitters in accordance with the ranges of the pitches at 0.43 and 0.58 seconds respectively. The individual measurements for each hitter are found in Table 3.

TABLE 3.—DISTANCE OF BASEBALL FROM HOME PLATE BEFORE START OF FORWARD SWING OF BAT

Player	Time of Swing (Seconds)	Distance from Home Plate (feet)	
		Speed of Pitch 0.43 sec.	Speed of Pitch 0.58 sec.
M. Alou	0.16	22.51	16.69
A. Asaro	0.20	28.14	20.86
D. Bennetch	0.18	25.33	18.78
W. Carr	0.16	22.51	16.69
D. Davis	0.22	30.95	22.95
J. Davis	0.20	28.14	20.86
R. Farley	0.26	36.58	27.12
T. Haller	0.16	22.51	16.69
C. Horn	0.18	25.33	18.78
W. Kern	0.16	22.51	16.69
D. Mann	0.18	25.33	18.78
M. Mota	0.28	39.39	29.21
F. Reveira	0.20	28.14	20.86
W. Spiers	0.18	25.33	18.78
L. Stubing	0.18	25.33	18.78
L. Thomas	0.23	32.36	23.99
G. Valentin	0.18	25.33	18.78
Mean Averages	0.19	27.40	20.31

Angular Measurements of Hitters' Movements

BODILY INCLINE DURING HITTING

How does the professional hitter control his bodily movements during the swing to avoid losing his balance? Newton explained that a body will remain in motion with constant velocity along its directed path unless acted upon by some external unbalanced force. To avoid losing his balance, the hitter must counteract the forces propelling the bat swiftly toward the baseball by leaning backward, extending his forward knee, raising the rearward leg and swinging it in a direction counter to the path of the bat, or reducing the force of his swing. The first two choices, widely applied in varying degrees by the 17 hitters, were measured in this study.

The measurements of the lateral and backward lean of the body were made at three stages in the hitter's total sequence of hitting: (a) the batter's stance, (b) the position immediately after the stride and before the pivot, and (c) the position wherein the bat contacted the baseball. Each of the first two measurements was made by measuring the angle formed by a horizontal line at the mid-point of the batter's feet, and a line connecting the mid-points of the hitter's feet and his shoulders at the top line of the shoulders. The third measurement was of the angle formed by the intersection of a horizontal line at the mid-point of the batter's feet and a line drawn from the mid-point of the batter's feet to his first thoracic vertebra. The camera was leveled before taking pictures of each hitter in order to make the horizontal lines consistent and reliable.

The mean averages of the 17 hitters are as follows: (1) stance, 88°, (2) starting point of the pivot, 88.3°, and (3) moment of contact with the baseball, 88.2°.

Thirteen of the 17 hitters leaned laterally toward the catcher during the stance; ten leaned laterally toward the catcher at the commencement of the pivot; and, 14 leaned backward toward the catcher during the moment when the baseball was being hit.

It seems that bodily lean representing a major factor in the total centripetal force may be indicative of its partner, the centrifugal force of the rotary movements of hitting. The nine hitters with the highest slugging averages of this group compiled a mean total of bodily lean of 86.4° degrees when the baseball was being hit. The individual measurements of the hitters are found in Table 4.

FORWARD KNEE EXTENSION WHEN THE BALL IS HIT

Two measurements were made of the hitter's forward knee (nearer the pitcher) extension in the movie frame wherein contact was made between the bat and the ball in order to increase the degree of validity of these findings. The first measurement was made of the intersection of the lines from the lateral malleolus of the fibula to the patella and from the patella along the anterior surface of the thigh. The second measurement was made of the intersection of the lines from the anterior surface of the thigh to the patella and from the patella along the anterior surface (toward the pitcher) of the lower leg. The second measurement deviated $+ 9.9°$ from the first.

The mean averages of the 17 hitters are 157.9° for the first measurement, and 167.8° for the second measurement. Ten of the hitters ranged between 150° and 159° degrees, and five between 160° and 169° degrees for the first measurement. Nine of the hitters ranged between 160° and 169°, and five ranged between 170° and 179° for the second measurement. Thus, with the exception of a single measurement for one hitter, there was no full, forward knee extension at the moment of contact with the baseball. The individual measurements of the hitters are found in Table 4.

REAR ELBOW FLEXION AT THE MOMENT OF HITTING

The angle of the rear elbow was measured in the movie frame showing contact with the baseball in order to determine the relative movement of the

TABLE 4.— ANGULAR MEASUREMENTS OF HITTING MOVEMENTS
(Degrees)

Player	Bodily Incline			Forward Knee Extension		Rear Elbow Flexion
	Stance	Before Pivot	Hitting Baseball	First Angle	Second Angle	
M. Alou	85.5	79.0	85.0	160.0	173.0	133.0
A. Asaro	87.0	88.0	91.0	152.0	165.0	98.0
D. Bennetch	87.0	90.5	89.5	169.0	179.0	102.0
W. Carr	91.0	90.0	89.0	155.0	165.0	135.0
D. Davis	86.0	89.0	84.5	152.0	160.0	112.0
J. Davis	89.8	93.0	89.3	153.5	163.5	107.5
R. Farley	88.0	85.0	81.0	163.0	173.0	130.0
T. Haller	86.5	85.5	88.5	164.5	173.0	115.0
C. Horn	86.0	86.0	87.0	149.0	159.0	114.0
W. Kern	89.0	85.5	83.0	151.0	158.0	110.0
D. Mann	92.0	96.0	95.0	155.0	166.0	123.0
M. Mota	89.3	96.3	99.0	156.0	169.0	104.5
F. Reveira	84.0	87.0	86.0	174.0	182.0	125.0
W. Spiers	92.5	90.0	89.5	155.0	161.0	77.0
L. Stubing	85.0	81.5	83.5	161.0	174.0	105.0
L. Thomas	86.8	84.8	80.0	158.5	167.5	129.0
G. Valentin	90.0	94.5	99.0	156.0	164.0	119.0
Mean Averages	88.0	88.3	88.2	157.9	167.8	114.1

arms and, indirectly, to consider the relative importance of the rotary movements in hitting. The angle of the rear elbow (nearer the catcher) was measured at the point of intersection between a line drawn from the wrist to the elbow and a second line from the elbow to the midpoint of the lateral view of the shoulder in the region of the deltoid muscle.

Ten of the 17 hitters had measurements between 98° and 120°, and all of the hitters had angles of 135° or less. The mean average of the elbow flexion for the group is 114.1°. The individual measurements are given in Table 4.

It should be recognized that the rear wrist or forearm must be supinated to provide the horizontal or level swing of the bat that is desirable at the moment of contact with the baseball. Recognizing this, the following conclusion is drawn: the elbow under such conditions must be in the proximity of the body when the angle of flexion approaches 90°. If the elbow is near the body during the critical moment of hitting the baseball, then the arms are relatively stationary until the follow-through begins. Thus, the action of the trunk (hips) rotation and the wrist action assumes even greater significance during the vital stages of hitting.

Level of the Head During Effective Hitting

The stride, the crouch forward over the home plate, and the bodily lean will alter the levels of the head during the total sequence of hitting and will require adjustments by the eyes and the muscles coordinating the move-

ments that are vital to effective hitting. Therefore, the relative change of the levels of the head during hitting was measured to determine the general limits within which professional hitters govern their over-all movements.

The measurements of the levels of the head were made at two points in the hitter's total sequence of batting movements: (a) the stance, and (b) the moment of hitting the baseball. The vertical distance from the horizontal level of the top of the hitter's head to the mid-point of his feet was measured.

Only one hitter raised the level of his head in the changes from his stance to the moment of hitting the baseball; the other 16 lowered their heads. The mean average for the 17 hitters showed a —6.5 percent of the body's height in the stance. The proportion between the increase or decrease in the level of each player's head and his greatest filmed height is recorded in Table 5.

TABLE 5.—STRIDE AND LEVEL OF HEAD DURING EFFECTIVE HITTING

Player	Stride (Inches)	Proportional Decrease or Increase of Head Level [a] (Percentage)
M. Alou	31.0	— 5.7
A. Asaro	5.3	— 7.0
D. Bennetch	6.2	— 5.6
W. Carr	11.9	—11.2
D. Davis	6.0	— 3.9
J. Davis	6.3	—12.6
R. Farley	8.1	— 8.9
T. Haller	10.9	— 3.2
C. Horn	11.7	—14.4
W. Kern	17.5	— 9.1
D. Mann	8.4	+ 1.1
M. Mota	11.7	—10.9
F. Reveira	10.7	— 2.5
W. Spiers	5.8	— 2.7
L. Stubing	10.7	— 3.6
L. Thomas	13.3	— 8.5
G. Valentin	5.2	— 1.5
Mean Averages	10.6	— 6.5

[a] The proportion that each player's increase or decrease in the level of his head was of the total filmed height of that player is given here.

Preparatory Batting Movements of the Stance

The emphasis placed on the stance and early movements of a hitter by coaches, players, and writers determined that this phase of hitting be analyzed. Measurements and attempts to correlate these findings with seasonal batting results were included as a complementary portion of this study of effective hitting. Measurements were made of the following associated endeavors to gain power or additional force: (a) the distance that the hands

on the bat were held from the central axis of the body's rotation[3] just before the forward bodily pivot, (b) the total degrees of recoil of the bat in a counter direction from the starting point of the effective forward swing of the bat (measured from the horizontal level of the hands), and (c) the degrees of cocking of the bat by the wrists (the change in degrees of movement of the bat from its position in the stance to the greatest extent of recoil).

The mean averages of these measurements for the 17 hitters are as follows: (a) the distance of the hands on the bat from the central axis of rotation of the body, 22.8 inches, (b) the total extra degrees of recoil, 107.5°, and (c) the cocking action of the wrists, 19.6°. The individual measurements of the hitters are found in Table 6 together with the seasonal batting and slugging averages.

TABLE 6.—RELATION OF RECOIL AND BACKWARD DISTANCE OF BAT TO BATTING AND SLUGGING AVERAGES

Player	Distance Bat-body (Inches)	Angle of Recoil (Degrees)	Cocking Angle (Degrees)	1959 Averages	
				Batting	Slugging
M. Alou	23.3	88	36.0	.288	.446
A. Asaro	21.0	109	29.0	.346	.488
D. Bennetch	22.7	111	15.0	.284	.465
W. Carr	21.0	81	22.0	.300	.452
D. Davis	26.0	128	17.0	.283	.401
J. Davis	26.3	110	0.0	.254	.412
R. Farley	22.7	129	36.0	.313	.457
T. Haller	20.6	91	17.3	.276	.385
C. Horn	23.3	115	6.5	.259	.395
W. Kern	30.9	89	10.0	.316	.532
D. Mann	20.0	113	31.0	.318	.458
M. Mota	20.1	113	25.0	.314	.449
F. Reveira	23.3	69	20.0	.380	.588
W. Spiers	25.2	116	23.0	.265	.388
L. Stubing	22.7	137	0.0	.300	.454
L. Thomas	20.0	133	42.0	.304	.500
G. Valentine	18.5	96	3.0	.311	.391
Mean Averages	22.8	107.5	19.6	.297	.446

All attempts to find correlation between these measurements and the seasonal batting and slugging averages were insignificant. Assuming that these preparatory movements are habitual and therefore generally maintained over the course of the season, there seems to be little justification for emphasis on these actions beyond gaining preparedness, alertness, free movement, and relaxation or comfort.

[3] The measurements of this distance were the same as for the radius of the rotary motion of the hands and wrists found under the heading "Relative Velocities of Major Bodily Segments."

Summary

The findings of this study indicate that the rotary motion initiated by rather dramatic hip rotation and culminated by quick and powerful wrist action is paramount among the movements employed by professional hitters while engaged in effective hitting. The value of the secondary motions rests on their responsibility in safeguarding the full limits of the forward thrusting, rotary force while maintaining bodily balance.

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Relationship between Explosive Leg Strength and Performance in the Vertical Jump[1]

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Abstract

The leg strength of 70 college men was measured in a position designed to involve the power thrust of the major muscle groups used in the vertical jump. The subjects then performed a modified Sargent jump that used no arm snap. Although the reliability of all measures was high, individual differences in the ratio of tested strength to body mass showed only a low and nonsignificant correlation with jumping performance. The results are interpreted to support the hypothesis that strength exerted against a dynamometer involves a different neuromotor pattern than strength exerted by the muscles during a movement. Tables of means, variabilities, and intercorrelations are included in the report.

THE VERTICAL JUMP is one of the oldest performance tests in physical education. Originally called Sargent's Physical Test of Man (14), it has been labeled a test of neuromotor efficiency (15), a test of the maximal rate of work output in proportion to body weight (10), and a test of dynamic strength (9). At present it is generally accepted as a measure of "explosive energy" (1), "primarily a test of the ability of the body to develop power in relation to the weight of the individual himself (2)." From the principles of physics, the ratio of the force per unit time applied to the mass of an object determines the speed with which it leaves the ground vertically; consequently the force/mass ratio determines the height of the jump.

While correlations between the jump and pooled strength items have been published (7, 8), only one study has been found that reports the relationship between individual differences in dynamometric strength of the major muscle groups involved and performance in a purely leg-action vertical jump. Incidental to a factorial analysis of the speed element in athletic performance, Rarick (13) reported an average correlation in 51 male college students of $r = .120$ between leg lift strength and a vertical jump without arm action. One other study has reported the strength-jump correlation. Harris (4) tested 163 junior high school girls, finding a coefficient of .215 between an undetailed measure of leg strength and the ordinary Sargent test, which is a jump that involves considerable arm action (11). Evidently there has been no investigation of the correlation between the leg action jump and leg strength scored in relation to individual body weight (i.e., the strength/mass ratio). Determination of this relationship is currently of importance in the

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light of the recent hypothesis that isometric strength as exerted against a dynamometer involves a different neuromotor pattern from that exerted during a movement (5).

The apparatus that was used for automatically measuring the vertical jump has been described in considerable detail by Pacheco (12), who found that subjects tested with it, using the modified Sargent jump without arm snap as in the present experiment, performed very consistently since the reliability coefficient was high. They showed very little learning. The recording apparatus used a cord attached to the subject's head. This cord passed vertically upward to a pulley and then downward and sideward to a spring operated reel which placed the cord under tension. A sliding indicator showed the height jumped on each trial. Each subject was given two practice trials, followed by five scored trials separated by three minutes rest between each trial.

Explosive leg strength was measured with a conventional leg strength dynamometer, using the belt method and proceeding as recommended by Clarke (2), except that the subject controlled his position with his back and hips sliding on a wall as suggested by Hubbard and Mathews (6) and contracted the leg muscles explosively. The position was adjusted to bring into play, insofar as practically possible, the major muscle groups that seemed to be utilized in the power thrust of the vertical jump. Immediately prior to the explosive muscle contraction, the subject took up the slack on the chain connected to the dynamometer by a preliminary tension so as to eliminate the spurious strength reading which might result from a sudden jerk. Three trials were given one day before the jump test, with five minutes rest between each trial. The subjects were 70 college undergraduate males. Calibration of the instrument was checked several times.

Results and Discussion

The data are given in Table 1. There is no significant correlation between the height jumped and either the strength/mass ratio or simple strength. Since strength in action as measured by the vertical jump is found to be unrelated to dynamometric strength, these data support the Henry and Whitley (5) hypothesis that the two types of muscular action are controlled by different neuromotor patterns.

TABLE 1.—DESCRIPTIVE STATISTICS AND CORRELATION COEFFICIENTS

Factors		Distributions		Correlations			
		M	σ	H	W	S	J
Stature (in.)	H	70.9	2.5	*.989*[b]	.653[c]	.152	.016
Weight[a] (lbs.)	W	164.6	19.9	.653[c]	*.991*[b]	.179	.043
Strength (lbs.)	S	955.	273.	.152	.179	*.974*[b]	.199
Jump (in.)	J	17.9	2.2	.016	.043	.199	*.970*[b]
Strength/mass[a]	S/W	5.64	1.69	—.124	—.243[c]	.903[c]	.168

[a] Since pounds are units of force, the weight and the strength/mass ratio must be divided by the acceleration from gravity (32 ft./sec.^{2}) if absolute units are desired.
[b] Reliability coefficients.
[c] The designated correlations differ significantly from zero (.237 required at the 5% level).

The correction for attenuation makes only a small change in the amount of relationship, since the reliability coefficients are quite high. Using the values given in the table, the correlation between the strength and jump changes from the raw figure of .199 to the corrected figure of .204, and the correlation between strength and the force/mass ratio (which is the relationship of theoretical interest) changes from the raw correlation of .168 to the corrected value of .174.

Even if these correlations were statistically significant, the amount of relationship would be far too low to be of importance. Every effort was made in this study to ensure that the conditions of the experiment were as conducive as they could fairly be to the appearance of a high relationship between the dynamometric strength and the strength in action. For example, the Sargent jump was used without arm snap because this form tends to have a higher correlation with the speed factor than the original form (13). The results furnish another instance of high neuromotor specificity.

The correlation found between strength and jump, .199, does not differ significantly from the Rarick correlation of .120 ($t = 0.4$). He did not investigate the strength/mass relationship. It is of interest that the height jumped by the present subjects does not differ significantly from that reported in the Rarick study ($t = 1.6$). In leg strength, the figures for this study are 60 percent greater than his ($t = 10.3$). Some of the difference may perhaps be accounted for by the technique of explosive exertion of strength against the dynamometer. Most likely, however, the use of the belt is the major factor, since it is known to give a much larger dynamometer reading (3). The uncorrected reliability for leg strength found in the present study, .941 (which is the average of the correlations between different trials on the dynamometer), is higher than usually reported (2). Possibly the use of the wall support is partially responsible (6).

In reading the references cited, as well as others related to the general topic, the writer has been impressed by a looseness of terminology and a resulting confusion of ideas in discussions of tests that are said to measure strength, but utilize chinning, dipping, push-ups, and the like. These are performances that involve resistance to fatigue rather than ability to exert high muscular force. The factor of ability to do performances of this type has been labeled dynamic strength; it is orthogonal to and thus unrelated to the factor of static (dynamometer) muscular strength (7, 8). It is not the same as the dynamic strength (strength in action) discussed in recent studies (5) related to the present one, which has more in common with the speed factor (identified by speed in sprinting) that has appeared in factor analyses as orthogonal to the static strength factor (4, 13).

The present study and the recent one by Henry and Whitley using an arm movement (5) concern a single large muscle performance in order to get closer to basic factors. Both studies center on static strength and the body action that would be the logical consequence of unleashing this strength to produce a bodily movement. While measured as speed in their study and distance jumped in the present one, it is "strength in action" in both. Here,

as in the earlier factor analyses cited above, the two types of strength are practically uncorrelated.

Perhaps our thinking will be clearer if we reserve the term strength for dynamometric measurements or muscular force computed from physical laws and designate the other type by a suitable word or phrase related to action ability. Further analysis and study of our action tests are needed, if we hope to understand the manner and extent of their relation to basic factors such as muscular force, muscular endurance, and momentum.

Conclusions

Individual differences in vertical jumping performance, as measured in this study, have little or no relationship to explosive leg strength or the ratio of leg strength to body mass. This finding supports the hypothesis that strength exerted against a dynamometer involves a different neuromotor pattern or program from that controlling the muscles during a movement.

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(Submitted October 12, 1960)

Notes and Comments

NOTES

Simple Reaction Times of Selected Top-Class Sportsmen and Research Students[1]

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This study was undertaken to test the hypothesis that the simple reaction times to a visual stimulus of top-class racket games players are significantly shorter than those of research students.

Procedure

Experimental Groups. Each group consisted of 20 men. The subjects designated as sportsmen were all international competitors in squash rackets or badminton and were of various nationalities. The subjects known as students were 20 men selected at random from a list of all research students at the University of Birmingham. These students were comparable to the sportsmen in sex (male) and age (20–30 years), had had fair opportunities for developing any sporting potentiality they might possess, and were of mixed nationality.

Apparatus. The apparatus used consisted of a telegraph key, a stimulating unit of three light bulbs in a row, and a chronometer, which was connected in a make-break circuit and recorded from 0 to 500 milliseconds to the nearest 5 milliseconds.

Method. The subject's reaction time was measured by his response to the cessation of a light stimulus. Each subject was tested individually. He was seated with his finger depressing the response key and the stimulus unit was on the desk straight before him. The chronometer was placed in an adjoining room or out of sight of the subject. Exactly the same procedure was followed for each subject. The instructions and demonstrations were made as simple as possible and in such a way as to stress the muscular reaction. Twenty practice trials were given, followed by two series of 25 trials with a minute break between the two series. No verbal signal was given after the first measurement of each series, for the act of replacing the finger served as a readiness signal to the subject. The foreperiod (i.e., the period of waiting for the light to go out) was varied to avoid anticipatory or rhythmical responses on the part of the subject. This time was kept between one and four seconds. The apparatus recorded the interval between the cessation of the visual stimulus and the release of the key. Movement time was therefore excluded from this study and reaction time only was measured.

Each reading was recorded on a prepared sheet together with additional notes on any variation from the normal in the condition of the subject or the experimental environment. This was necessary because, although every effort was made to standardize the conditions, the sportsmen were tested in the sports clubs where they were competing. On five occasions the sportsmen had to be tested after participation in a strenuous match, and Elbel's (2) findings suggest that the emotional stimulation of competitive games

[1] The experimental work was carried out by L. Goldthorpe as part of the requirements in his final year of study for the degree of Bachelor of Arts, University of Birmingham, and much of this article is based on his report.

tends to speed up reaction times. On one occasion a small amount of alcohol had just been drunk, which could affect reaction time. Variations in the degree of illumination of the room and in background noise could also affect results.

The reliability of the test, ascertained by means of the parallel-split technique (1), was $+.846$. The halves used were the means of the first 25 trials and those of the second 25 trials of each research student. (It is interesting to note that a higher estimate of reliability of $+.95$ was obtained when the sportsmen's results were used.)

Results and Discussion

The two series of 25 responses were added together and used to compute the average response time for each individual. All readings were used on the grounds that all reactions are relevant in a game situation. The mean reaction time for each group is shown in Table 1 together with the t and probability values. The F test showed that the standard deviation between individuals was similar for sportsmen and for students so that the standard t test could be applied. The difference between the mean reaction of the sportsmen and that of the students was highly significant.

TABLE 1.—REACTION TIME MEANS, STANDARD DEVIATIONS, AND T SCORES OF SPORTSMEN AND STUDENTS

Subject Groups	N	Reaction Times			
		Arithmetic Mean	S.D.	t	P
Sportsmen	20	.207 secs.	.0194 secs.	4.38	less than .01
Students	20	.235 secs.	.0196 secs.		

Having established that the mean reaction times were different for sportsmen and students, the variability of individual reaction times was next examined. An estimate s^2 of the variance was calculated for each group of 25 trials for each sportsman and student. The estimates s^2 were not, however, normally distributed so the transformation $z = \frac{1}{2} \log_e s^2$ was made. It was then possible to test whether the variation of the first group of 25 readings as measured by z was significantly different from the variation of the second group of 25 readings for either the students or the sportsmen by means of a t test using the technique of paired comparisons. The result of this test showed no significant difference, not even at the 25 percent level, between the first group of 25 trials and the second group of 25 trials for both students and for sportsmen.

The two values of z obtained for each person were considered as two estimates of the same measures of variation. It was then possible to obtain estimates of the variance of z for a student and the variation of z between students by means of a 2×20 analysis of variance. Similarly, these estimates were obtained for sportsmen.

Using the average of the two values of z for each person, a t test was performed to compare the mean z scores for students and for sportsmen (see Table 2). It was found that the difference between the values of z for sportsmen was significantly less (at 1 % level) than the values of z for research students. This shows that the variation in the reaction times of sportsmen is significantly less (at 1 % level) than the variation in the reaction times of research students.[3] The difference of .67 between the z scores corresponds to a ratio of 1.9 in the standard deviations of individual test scores as between students and sportsmen.

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[3] This work was carried out by P. V. Bertrand.

TABLE 2.—MEAN Z SCORES, STANDARD DEVIATIONS AND T SCORES FOR SPORTSMEN AND FOR STUDENTS

	Arithmetic Mean	S.D.	t	P
z scores for sportsmen	2.96	.378		
z scores for students	3.63	.331	5.5	less than .01

The results show a highly significant difference in the reaction times of the two groups and also in the variation in the reaction times. Whether the sportsmen's shorter reaction time and smaller variation in reaction times were prerequisites to their success in sport or were due to their participating regularly in sport is debatable. The former view would seem to be more likely for at top-class level where a peak of fitness has been achieved and where technique has been perfected, very fine discriminatory factors are involved. This study suggests that reaction time may well be one of these factors.

Summary and Conclusion

1. The reaction times of the sportsmen were significantly shorter than those of the research students.
2. The variation in the reaction times of the sportsmen was significantly less than the variation in the reaction times of the research students.
3. This study would seem to support the hypothesis that the simple reaction times to a visual stimulus of top-class racket games players are significantly shorter than those of a normal sample of the population as represented by a random sample of research students.

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(Submitted November 3, 1960)

Comparison of Electrocardiograms of Small Animals Using an Oscilloscope and Direct-Writer [1]

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Standards set by the American Medical Association require the frequency response of direct-writers to be adequate to record faithfully the human electrocardiogram. The heart rate in the testing state varies between about 40 and 100 beats per minute. Heart rates of rats, on the other hand, may range from 300 to 500 and of mice from 400 to 900 beats per minute. It is conceivable, therefore, that the electrical events in the hearts of these small animals occur so rapidly that the usual direct-writer, because it is partially a mechanical system, cannot record these events accurately.

[1]Supported in part by Michigan State University Research Grant, Number 941, 1957.
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[3] Now at Temple University, Philadelphia, Pennsylvania.

Since in our laboratory we became interested in studying the relationship between exercise and electrocardiograms in small animals, it was necessary to determine the adequacy of direct-writers for use with rats and mice. A "Cardiotron" and a two-channel Sanborn recorder for taking electrocardiograms in humans have been employed. The Sanborn recorder has the advantage of many paper speeds. It is possible to increase the speed to 100 millimeters per second, four times that normally used with humans. This does not improve the frequency response, of course, but by spreading the events horizontally, it becomes easier to measure the various intervals and amplitudes. In preliminary work these direct-writers did not appear to record ECG's of mice accurately, and even those of rats seemed questionable.

Rappaport and Rappaport (1) reported that the usual electrocardiograph (Sanborn "Cardiette") does not accurately record the electrocardiograms of mice. The QRS and T-waves showed appreciable distortion. They concluded that the usual galvanometer speed of 0.01 seconds was inadequate and recommended a galvanometer response of 0.0015 seconds.

The electrical potential recorded in electrocardiograms of small animals is normally not as great as that observed in humans. Generally, by increasing the standardization by 50 percent, deflections roughly comparable to the human electrocardiogram are secured. However, this increases the amplification of line current and other noise. In order to minimize this interference, a copper screen enclosed cage was constructed (See Figure I). The animals were under light anesthetic (sodium pentabarbital) when the electro-

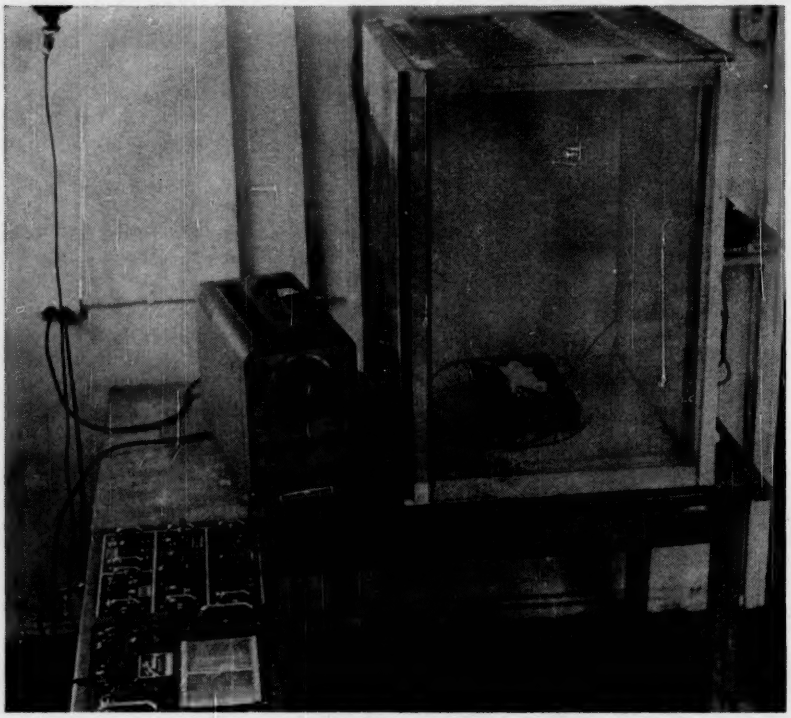

FIGURE I. Position of rat in copper cage when electrocardiogram is taken.

cardiograms were taken. The electrodes were hypodermic needles soldered to the usual ECG cables and were inserted under the skin. The electrical potentials were fed into an oscilloscope and the two-channel recorder simultaneously. By means of a Polariod Land camera attached to the oscilloscope, simultaneous records of the electrocardiogram were obtained.

Results

Typical comparisons of rat electrocardiograms are illustrated in Figures II and III. The T-wave appears to be recorded fairly well by the direct-writer, but the QRS complexes

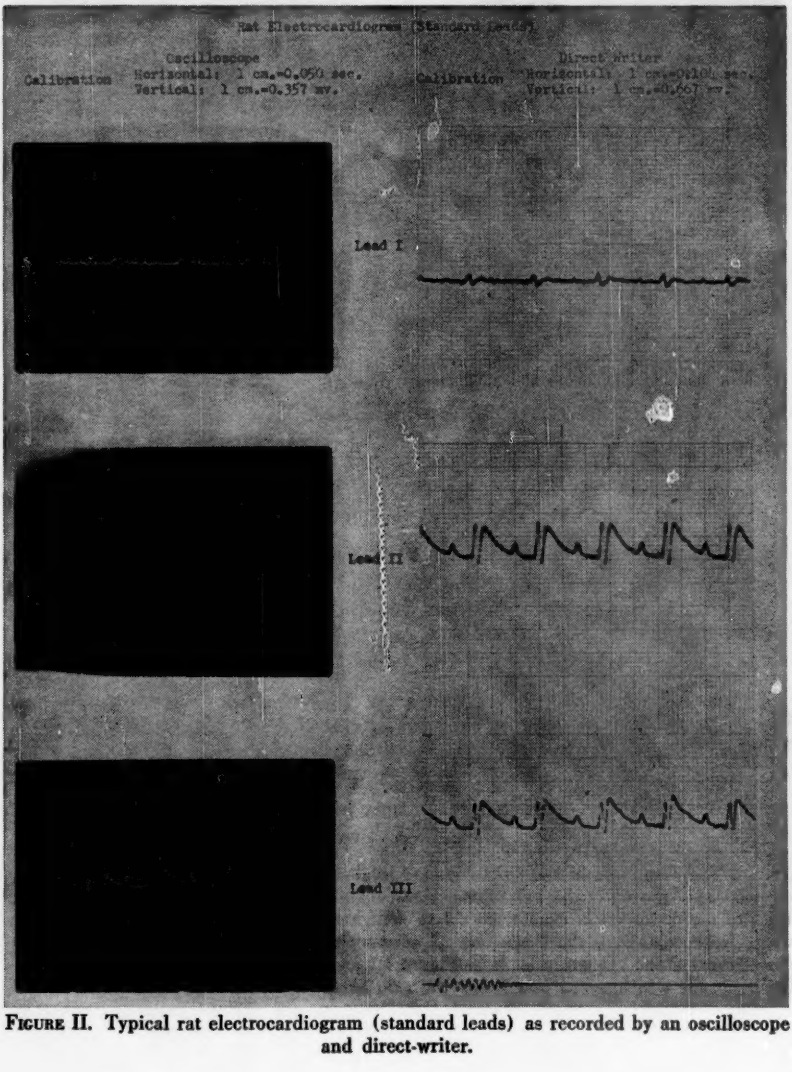

Figure II. Typical rat electrocardiogram (standard leads) as recorded by an oscilloscope and direct-writer.

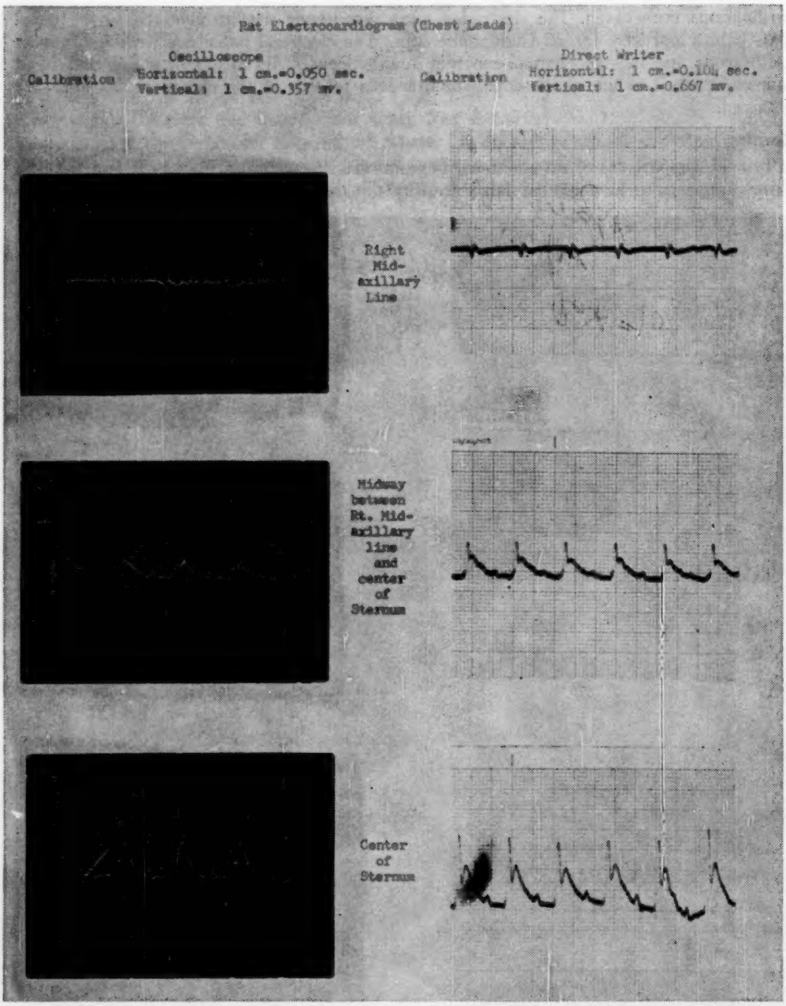

FIGURE III. Typical rat electrocardiogram (chest leads) as recorded by an oscilloscope and direct-writer.

are not. The amplitude in the QRS complex is about 10 to 15 percent greater with the oscilloscope. Apparently the galvanometer response is inadequate and/or the mechanical stylus of the direct-writer cannot move fast enough to record faithfully the events taking place. In these animals the T-wave occurs soon after the QRS. The Q-wave is absent in almost every animal in every lead. In Figure III are shown several chest leads of a rat. The electrode was inserted just below the skin at the positions indicated.

The standard leads in a mouse are presented in Figure IV. Here again, the T-wave is recorded fairly accurately, but the amplitudes of the QRS complex are 20 to 30 percent greater in the oscilloscope recording. The T-wave occurs even sooner in the mouse than in the rat. From just a cursory observation it appeared clear to us that the direct-writing instruments are not accurate enough for recording the mouse electrocardiogram.

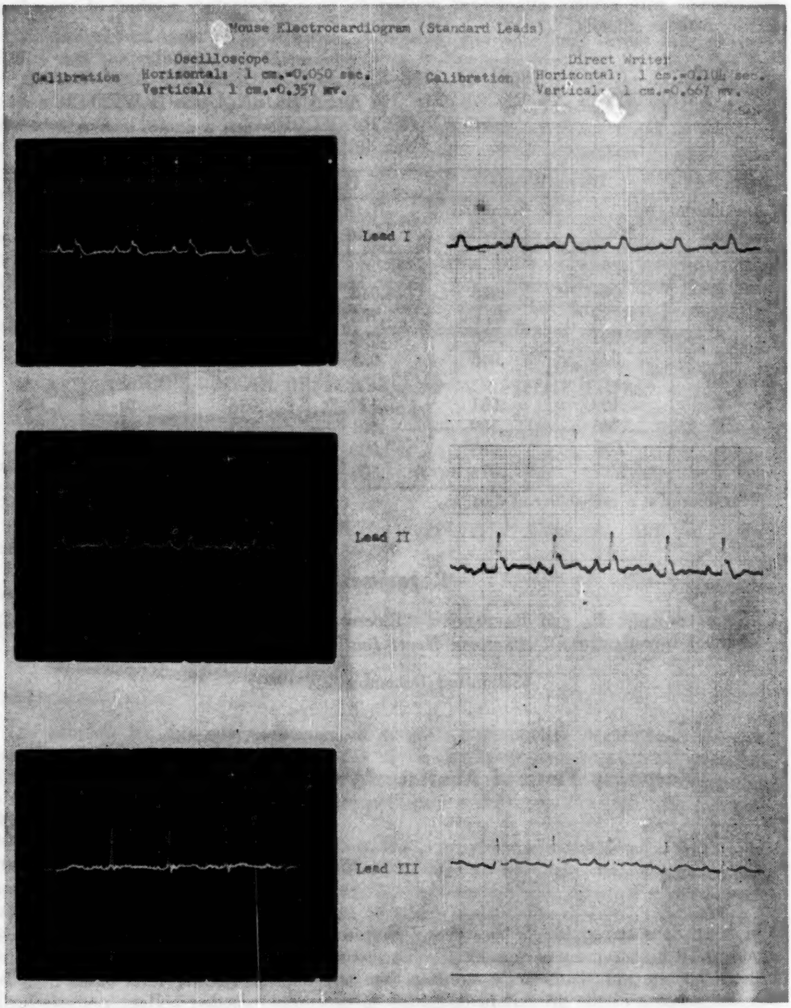

Figure IV. Typical mouse electrocardiogram (standard leads) as recorded by an oscilloscope and direct-writer.

Since the rat electrocardiogram pattern was similar in the two instruments, it was necessary to make a more detailed analysis of records secured on the two instruments. The results of simultaneous recordings of standard limb leads on 48 rats are reported in Table 1.

The results indicate that the QRS waves in the electrocardiogram of small animals (rats and mice) are not accurately recorded by direct-writing electrocardiographs. The oscilloscope with camera attachment appears to be a satisfactory method of recording ECGs in these animals.

TABLE 1.—COMPARISON OF THE RAT ELECTROCARDIOGRAM WAVE AMPLITUDES AS RECORDED ON A SANBORN DIRECT-WRITER AND AN OSCILLOSCOPE
(N = 48)

Amplitude (mv.)	Direct-Writer		Oscilloscope		t	r
	Mean	Standard Deviation	Mean	Standard Deviation		
Lead I						
P	.044	.026	.046	.039	.35	.60[a]
R	.139	.071	.186	.079	3.10[a]	.75[a]
S	.056	.056	.093	.066	2.92[a]	.83[a]
T	.043	.046	.051	.046	.86	.63[a]
Lead III						
P	.169	.031	.172	.036	.40	.64[a]
R	.346	.109	.421	.139	2.88[a]	.87[a]
S	.020	.065	.090	.109	3.76[a]	.64[a]
T	.297	.074	.300	.078	.19	.81[a]

[a] Significant at a probability of 0.01.

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(Submitted December 20, 1960)

Response Time of Amateur Wrestlers[1]

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In a previous paper (9), it was shown that wrestlers of championship level achieve significantly higher mean scores on the Total Proportional Strength test than do nonathletes but are not significantly stronger than wrestlers of a lower level of ability. It was the purpose of the present investigation to determine whether college nonwrestlers, college wrestlers, and champion United States and foreign wrestlers are characterized by differences in reaction and movement time.

[1]Research Report 60-22.H.

Review of Literature

Only two studies of the quickness of response of wrestlers have been located in the literature. Keller (2) employed an apparatus in which the subject had to move 24 in. and knock over one of three possible targets as designated by a visual stimulus. He found that athletes scored significantly better than did nonathletes and that sports appeared to fall into groups. The faster included baseball, basketball, football, and track; the slower included gymnastics, swimming, and wrestling. From this he concluded that the requirements for quickness of bodily movement are not the same for all sports and that a person with relatively slow total body reaction time has a better chance of attaining success in individual than in team activities. Kroll (3) used two measures, one in which a subject moved forward and dropped to his knees in response to a visual signal, and one in which he jumped backward off a platform in response to a visual signal. There were no significant differences between successful and unsuccessful high school wrestlers on either of the response times measured.

Neither Keller nor Kroll fractionated the response time into reaction time and movement time, as, for example, Pierson (5) has done in his work with fencers, although both Guilford (1) and Miles (4) consider impulsion (rate at which movements are initiated from a stationary position) and speed (rate of movements after they have started) separate psychomotor factors, and it would appear that they must be measured individually if valid conclusions are to be drawn from studies of response time.

TABLE 1.—MEAN RESPONSE AND MOVEMENT TIMES (in seconds)

		RT		MT		Age	
Subjects	N	Mean	S.D.	Mean	S.D.	Mean	S.D.
Non-wrestlers	40	.223	.025	.124	.017	18.7	3.0
Collegiate wrestlers	11	.227	.032	.118	.020	19.4	2.4
AAU wrestlers	32	.241	.034	.130	.021	24.5	4.6
JAWA	11	.250	.020	.143	.022	—	—

Procedure

The subjects for this study consisted of 40 male nonwrestlers drawn from an elective class in self-defense at the University of California at Los Angeles; 11 members of the 1960 wrestling squad at the same university; 32 outstanding wrestlers competing in the 1960 Amateur Athletic Union championships;[2] and 11 men from the 1960 Japanese Amateur Wrestling Association team.

The apparatus used in the present study has been previously described (8). Briefly, it consisted of a stimulus lamp which was activated simultaneously with a chronoscope, a microswitch which upon release stopped this chronoscope and activated a second one, and a photoelectric beam, the interruption of which stopped the second clock. Reaction time (RT) was then read from the first chronoscope and movement time (MT) from the second. The subject was seated in front of the apparatus and instructed to respond to the stimulus by releasing the switch and extending his hand through a light beam. The distance from the microswitch to the light beam was 11 in., and the subject was seated in such a manner that full extension of the dominant arm would place the finger-

[2]The writers are indebted to Dr. Albert De Ferrari, National AAU Wrestling Chairman, and to Mr. Robert B. Leibe, Athletic Director, The Olympic Club, for their cooperation in making it possible to test these wrestlers during the AAU tournament.

tips about one in. beyond the light beam. In accordance with the findings of Pierson and Rasch (7), the last 5 of 20 trials were recorded for each subject. Differences in group mean scores were analyzed by the t test and no difference was considered significant unless the chance occurrence of one of such magnitude was 5 percent or less.

Results

The results of the collection of the data are presented as Table 1. RT and MT scores of the various American groups did not differ significantly except for the RT of the AAU wrestlers and the nonwrestlers ($t = 2.51$). The AAU wrestlers were also older than either the college wrestlers or the nonwrestlers ($t = 3.47$ and 4.51, respectively). Since it has been established that RT and possibly MT are functions of age,[3] the raw scores were corrected for this factor by reference to the Pierson and Montoye age-regression curves (6). There were no differences in the corrected RT or MT scores of the college wrestlers, the AAU wrestlers, or the nonwrestlers, which could not be attributed to chance (t for AAU wrestlers and nonwrestlers RT = 1.0).

The Japanese wrestlers appeared to be of an age and experience comparable to that of the AAU wrestlers, but language difficulties made it impossible to be certain that their ages were correctly ascertained. When the raw scores for RT and MT for the Japanese were compared with those of the AAU wrestlers, differences were not significant ($t = 0.86$ for RT and 0.21 for MT).

The results of this study indicate that there are no significant differences in reaction time or movement time among collegiate nonwrestlers, collegiate wrestlers, and championship level American wrestlers when the various groups are equated for age. Japanese wrestlers do not appear to differ in these respects from American wrestlers of apparently comparable age and experience.

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[3]Discussions concerning this may be found in Chapter 3, "Psychological Aspects of Aging," by S. H. Bartley, in *Vision of the Aging Patient*, edited by M. J. Hirsch and R. E. Wick, Philadelphia: Chalton Co., 1960 "Experimental Studies of Changes in Performance with Age," by A. T. Welford, *et al.*, in *Old Age in the Modern World*, Edinburgh: E. & S. Livingstone, Ltd., 1954; "Reaction Time," in *Experimental Psychology*, rev. ed. by R. S. Woodworth and H. Schlosberg, New York: Henry Holt & Co., 1954, and "Psychomotor Performance," by A. T. Welford, in *Handbook of Aging and the Individual*, edited by J. E. Birren, Chicago: University of Chicago Press, 1959.

9. RASCH, PHILIP J.; PIERSON, WILLIAM R.,; O'CONNELL, EUGENE R.; and HUNT, M. BRIGGS. "The Effect of Training for Amateur Wrestling on Total Proportional Strength Scores." *Research Quarterly* 32: 201-07; May 1961.

(Submitted December 13, 1960)

Status of College Male Students on Kraus-Weber Tests

OMER JOHN RUPIPER
University of Oklahoma

This study sought to determine the number of failures on the Kraus-Weber tests for physical fitness that were evident among college male students enrolled in physical education classes and to compare the mean differences in age, height, and weight between the pass and fail groups.

Procedure

The subjects were 119 undergraduate male students enrolled in six physical education courses at the University of Oklahoma. A plurality of the subjects were freshmen with smaller numbers of sophomores, juniors, and seniors. The six physical education classes were: basketball and soccer, beginning golf, tumbling and apparatus, badminton and handball, tennis and volleyball, and beginning swimming. The Kraus-Weber tests were given to all students by the same instructor in physical education who was trained to administer the tests.[1] If a student failed any one of the six subtests, it constituted a failure for the entire test. At the time of testing, near the end of the semester in which the subjects were enrolled, the age, height and weight of the participants were obtained.

TABLE 1.—MEAN AGE, HEIGHT, AND WEIGHT OF COLLEGE MALE STUDENTS WHO PASSED AND FAILED THE KRAUS-WEBER TESTS

Factors	Pass (N = 90)	Fail (N = 29)
Age (Mo.)	255.45	242.87
Height (In.)	69.67	69.89
Weight (Lb.)	161.20	161.63

Results

The mean age, height, and weight of the groups tested are shown in Table 1. The means for the variables in the pass group were compared with those in the fail group. Since the average height and weight for the groups were approximately the same, no tests of significance were computed. The mean age difference between the pass and fail groups was statistically significant beyond the 0.05 level ($t = 2.093$), where the pass group was 12.58 months older than the fail group. The majority of failures (60%) were attributed to the test for flexibility; no students failed the test for strength of abdominal muscle, i.e., abdominals minus psoas. The results of this study gave no indication that failures on the Kraus-Weber tests by college physical education male students were associated with height or weight, but the age of the students was significant factor.

(Submitted December 8, 1960)

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[1] Appreciation is expressed to Jack Shirley, now at the University of Nevada, for administering the tests and to the members of the physical education classes who participated in the investigation.

Physical Fitness of 7th Grade Children

OMER JOHN RUPIPER
University of Oklahoma

The present study was undertaken to investigate the muscular fitness of 7th grade children in a small town in southwestern Oklahoma. Other purposes of the study were to compare the results of the six subtests of the Kraus-Weber battery by sex and to determine if participation in sports activities outside of school makes a difference.

Procedure

Two graduate students with majors in education and minors in physical education had been trained to administer the Kraus-Weber Test. The tests were administered to a total of 345 7th grade children in a single junior high school during their regularly scheduled physical education period. The height and weight of the children were determined at the time of testing. The children were also asked to report their date of birth and whether or not they participated in sport activities beyond those offered at school. A separate scoring card was used to record the biographical information of each child and the results of his test performance.

The sample consisted of 168 boys and 177 girls in the 7th grade. The chronological ages for the boys ranged from 137 to 188 months with a median age of 155 and a mean age of 156.90 months; the ages for the girls ranged from 133 to 167 months with a median age of 155 and a mean age of 154.72 months. The heights ranged from 56 to 72 in. for the boys with a median height of 62.17 and a mean height of 62.89 in. The girls' heights ranged from 51 to 70 in. with a median height of 61.93 and a mean height of 62.24 in. The weights for boys ranged from 65 to 162 lbs. with a median of 102 and a mean of 103.46 lbs. The girls' weights ranged from 72 to 193 lbs. with a median weight of 105 and mean of 110.83 lbs. All students tested were regularly enrolled in physical education.

Findings

The highest percentage of failures was found on Test 6 for the 7th grade boys and for the total sample. The larger percentages of failures for the girls, which were relatively similar, were found on Tests 2, 3, and 6. A comparison was made between the 52 (30.95%) boys and 78 (44.07%) girls who failed the test. The chi square test for difference between the frequencies was 5.77 and significant beyond the 0.05 level. The difference between the failure for boys who participated in sports and those who did not participate was not statistically significant. The obtained chi square was 0.57. However, for girls there was a significant difference beyond the 0.05 level with an obtained chi square value of 4.55 in favor of those who participated in sports outside regular school activities.

(Submitted September 20, 1960)

COMMENTS

Personality Traits of Athletes as Measured by the MMPI: A Rebuttal

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In rebuttal to articles printed in recent issues of the *Research Quarterly* in which Keogh (2) and Rasch, Hunt, and Robertson (4) refer to "Personality Traits of Athletes as Measured by the *MMPI*" (1), the following arguments and explanations are submitted. Keogh indicates that the differences reported between the mean scores for the groups of athletes and nonathletes on certain variables of the *MMPI* may be attributed to chance. He also infers that there is lack of direction in the findings which further diminishes the significance of the results reported in the study.

In answer to the criticism that the differences found may be attributed to chance, it should be pointed out that three of the four F's obtained by the analysis of variance of the data for the groups of athletes and nonathletes meet the requirements for significance at the .01 level (as well as the requirements for significance at the .05 level as reported in the study). This fact would minimize the suspicion that the four significant F's reported might be the function of chance on the premise that in 42 analyses one could expect four significant F's (P = .05) for random samples from a single population. Table I contains the F's for the variables.

TABLE 1.—ANALYSIS OF VARIANCE OF MMPI VARIABLES FOR FRESHMAN NONATHLETES (N = 63), FRESHMAN ATHLETES (N = 71), UPPER-CLASS NONATHLETES (N = 74), AND VARSITY ATHLETES (N = 78)

Variables	Sources	SS	df	MS	F
Mf	Groups	2543.16	3	73.81	
	Within Groups	27162.65	282	65.50	8.8011[a]
	Total	29706.31	285		
A	Groups	633.71	3	211.24	
	Within Groups	12645.33	282	44.84	4.7109[a]
	Total	13279.04	285		
Do	Groups	126.59	3	42.19	
	Within Groups	1595.45	282	5.66	7.4572[a]
	Total	1722.14	285		
Re	Groups	95.18	3	31.72	
	Within Groups	2974.15	282	10.55	3.0077[b]
	Total	3069.33	285		

[a] Significant at or beyond 1 percent level of confidence, F for P of .01 = 3.86, df = 3,282
[b] Significant at or beyond 5 percent level of confidence, F for P of .05 = 2.64, df = 3,282

In regard to the comment that the findings do not show direction, the following facts are presented for consideration. In all comparisons of groups of athletes and nonathletes on the interest (Mf) variable, the groups of athletes have the lower scores. When upper-class and freshman nonathletes are compared on this variable the difference is not significant. Again, the difference is not significant when freshman and varsity athletes

are compared. Direction is well established on this variable, and the finding supports the conclusion that athletes and nonathletes do score differently on the MMPI.[1]

In the comparisons of athletes and nonathletes on the anxiety (A) variable, the varsity athletes again score significantly lower than any group of nonathletes. The group of varsity athletes also scores significantly lower than freshman athletes, but when freshman athletes and upper-class nonathletes are compared the difference is not significant. The results of these cross comparisons indicate that varsity athletes score differently on this variable than do nonathletes and that age or class standing alone does not seem to influence the scores.

In comparisons of athletes and nonathletes on the dominance (Do) variable, both varsity athletes and upper-class nonathletes scored higher than freshman athletes and nonathletes. In addition, when groups of upper-class competitors are compared with the freshman competitors on the dominance variable, the scores for the upper-class group are significantly higher than the scores for the freshman group. These findings are interpreted as indicating that for this variable, class standing or age is a factor. This is noted as follows in the original report: ". . . which comparisons indicated that the upper-class students scored significantly higher on the dominance (Do) variable than the freshman students." (1)

On the social responsibility (Re) scale, upper-class nonathletes scored significantly higher than the freshman athletes, the freshman nonathletes, and the varsity athletes. This difference is reported, but no interpretation is attempted because the study offered no opportunity for cross comparisons.

The findings obtained from the analyses of the groups of participants in the various types of sports also demonstrated direction. On both the depression (D) and the psychasthenia (Pt) variables the varsity athletes who participated in individual sports scored significantly higher than varsity athletes who participated in both individual and team sports. On the depression (D) variable, the varsity athletes who participated in only individual sports scored significantly higher than the varsity athletes who participated only in team sports. On the psychasthenia (Pt) variable, the difference between the mean of the group of varsity athletes who participated in only individual sports and the mean of the group who participated in both individual and team sports is not significant, which precludes complete agreement between the findings for the two variables. Because other studies (3, 5) have listed positive correlations of .44, .69, and .57 between the scores on the depression (D) and psychasthenia (Pt) variables, the differences found in the study under discussion lend some support to the directional aspects indicated.

In reply to the reference of Rasch, Hunt, and Robertson (4) regarding the Booth Scale as a predictor of competitive behavior, this writer was—and is—very much aware of the limitations of the 22 item scale which in *one* instance demonstrated a positive correlation with estimates of competitive behavior. The summary and conclusions in the original article contain a recognition of the need for further study to establish or reject the validity of the scale.

Rasch and his associates present findings which indicate that for varsity wrestlers at the University of California at Los Angeles and the University of Oklahoma, the scale does not give a valid evaluation of estimates of competitive behavior. The fact that in the Rasch study a forced ranking procedure was used to classify in terms of competitive behavior a very select group of competitors seriously limits the opportunity to examine the validity of the scale. It is unlikely that any of the wrestlers could logically be classified as "poor" competitors.

In conclusion, it is believed that the findings presented in "Personality Traits of Athletes as Measured by the MMPI" are presented in a manner such that any critical

[1] An error in the listing of groups has been noted in Table 3, page 131 of the original published report. The second comparison in the table should be of freshman nonathletes and upper-class nonathletes rather than freshman nonathletes and freshman athletes. The figures in the table are correct.

reader who is acquainted with and has a regard for the complexities associated with investigations of personality and behavior will not be misled. The findings reported in the study are believed to support the conclusions listed in the original study.

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3. MCKINLEY, J. C., and HATHAWAY, S. R. "Scale 7 (Psychasthenia)." in *Basic Readings on the MMPI in Psychology and Medicine.* George S. Welsh and W. Grant Dahlstrom, editors. Minneapolis: University of Minnesota Press, 1956. p. 86.
4. RASCH, PHILIP J.; HUNT, M. BRIGGS; and ROBERTSON, PORT G. "The Booth Scale as a Predictor of Competitive Behavior of College Wrestlers." *Research Quarterly* 31: 117; March 1960.
5. WHEELER, W. M., LITTLE, K. B.; and LEHNER, G. F. J. "Internal Structure of the MMPI." in *Basic Readings on the MMPI in Psychology and Medicine* George S. Welsh and W. Grant Dahlstrom, editors. Minneapolis: University of Minnesota Press, 1956. p. 259.

(Submitted October 17, 1960)

Research Abstracts

Prepared by the Research Abstracts Committee of the Research Council, D. B. VAN DALEN, Chairman

69. ALEKSEEV, M. A. "K analizu fiziologicheskikh mekhanizmov nekotorykh form avtomatizirovannyk dvizhenii cheloveka." (A contribution to the analysis of the physiological mechanisms of some forms of automatized movements in man.) *Zh. vyssh. nervn. Deiatel.* 9: 354-63; 1959.

Bioelectrical activity of the hand flexor was studied in adults in response to rhythmic presentation of conditioned auditory stimuli, eliciting flexion of the forefinger, ergographically recorded. "At the beginning of the elaboration of such a rhythmic stereotype, wide effector generalization of the excitatory process was observed in the kinesthetic analyzer, expressed in the excitation not only of the muscle fibers performing the special reaction of finger flexion, but of other muscular groups as well. The nature of the activity of the latter is fully determined by the conditions under which the rhythmic stereotype is formed. As the latter is stabilized, this activity becomes extinct, which points to a concentration of excitation in certain parts of the kinesthetic analyzer." It is assumed that the concentration is to a considerable extent accounted for by a conditioned reaction to time, elaborated by the rhythmic sequence of conditioned stimuli. The concentration of excitation in the kinesthetic analyzer is disturbed when the stereotype is suddenly changed and when the conditioned signal is repeated over a period of time.—*D. B. Van Dalen.*

70. AMATORA, MARY. "Interests of Preadolescent Boys and Girls." *Genetic Psychological Monographs* 61: 77-113; February 1960.

Data were gathered from 12 schools located in 10 states widely distributed in the United States. Ninety percent of the interests feel into 10 categories. The total strength of each interest category taking degree of choice into account, was determined by the preparation of weighted scores. These interest categories varied in intensity with age and sex, and recurred in all parts of the United States. The 10 categories were: things owned, good life, vocation, relatives, travel, school, pet, money, education, and health.—*D. B. Van Dalen.*

71. ANDERSON, RICHARD C. "Learning in Discussions: A Resume of the Authoritarian-Democratic Studies." *Harvard Education Review* 29: 201-15; 1959.

Forty-nine studies are reviewed in which authoritarian and democratic leadership have been experimentally compared. It is concluded that: (a) "the evidence available fails to demonstrate that either authoritarian or democratic leadership is consistently associated with higher productivity," and (b) "the authoritarian-democratic construct provides an inadequate conceptualization of leadership behavior."—*D. B. Van Dalen.*

72. BURNS, ROBERT K., and CORSINI, RAYMOND J. "The Ideas Technique in Conference Leadership." *Group Psychotherapy* 12: 175-78; June 1959.

The ideas technique is an acrostic formula for a conference leadership approach to problem solving. The technique consists of: I-Introduction, in which the leader presents the content material for about 30 minutes; D-Demonstration, in which the leader has some aspects of the problem demonstrated by 2 or more people who role-play some scene related to the problem for 20 minutes; E-Exercises, which are primarily "buzz" sessions of either role playing as demonstrated above or a discussion on the lecture material, 30 minutes; A-Action, the group is re-assembled and the following may result: statements by leaders of the subgroup on what happened, exposition of role-playing situations at the tables, or questions from the group and answers from the leader for 20 minutes; S-Summary, the leader may summarize the session, giving his own remarks, or giving material emanating from the groups for about 20 minutes.—*D. B. Van Dalen.*

73. Cerretelli, P. "Some Aspects of the Respiratory Function in Man Acclimatized to High Altitudes (The Himalayas)." *Internationale Zeitschrift für angewandte Physiolgie einschliesslich Arbeitsphysiologie* 18: 386-92; 1961.

Vital capacity, inspiratory reserve volume, expiratory reserve volume, tidal air, maximal pulmonary ventilation during exercise (MEV), the composition of alveolar gases at rest, and the resting ventilation were measured on eleven male subjects from 26 to 47 years of age during stays at sea level, and altitudes of 3800-5000 meters, and 5000-7500 meters. A striking drop in vital capacity and MEV were found during the 30 days of acclimatization at each altitude.—*J. Royce.*

74. Coleman, James S. "The Adolescent Subculture and Academic Achievement." *American Journal of Sociology* 65: 337-47; January 1960.

The athlete has high status in the adolescent subculture because he holds the key to his school's prestige among other schools. On the other hand, the outstanding student has little or no way to bring glory to his school and receives more ridicule than reward for his efforts from his peers. It seems that higher evaluation of muscle over mind is a factor contributing to poor academic achievement among students with greater than average intellectual abilities as well as the mediocre.—*D. B. Van Dalen.*

75. Costello, C. G., and Eysenck, H. S. "Persistence, Personality, and Motivation." *Perceptual and Motor Skills* 12: 169-70; 1961.

Seventy-two children in 8 groups of 9 children each between the ages of 14 and 17 were selected on the basis of the Junior M. P. I. in such a manner that extreme high and low scorers on neuroticism and extraversion were selected, producing four combinations. The mean strength of each hand was adequately assessed and two-thirds of the mean strength was calculated. S was given two trials of persistence at this strength setting. The mean of the two was the S's persistence score. Results showed the extraverted to be significantly more persistent.—*C. Etta Walters.*

76. Cratty, Bryant J. "Athletic and Physical Experiences of Fathers and Sons Who Participated in Physical Fitness Testing at Pomona College, 1952-1959." *California Journal of Educational Research* 10: 207-211; November 1959.

Questionnaire responses of 24 fathers and their sons indicated that those passing the tests were, on the average, lighter in body-weight; had usually participated in high school athletics; had engaged in manual labor as a part-time high school job; and held a slightly higher opinion of physical education than did those who failed the tests. The fathers, as a group, were generally shorter and lighter in weight, and had participated slightly less in high school athletics, in high school physical education programs, and in manual labor than had their sons. In addition, the fathers held a lower opinion of the physical education program than did the sons.—*D. B. Van Dalen.*

77. Donald, Marjorie N., and Havighurst, Robert J. "The Meanings of Leisure." *Social Forces* 37: 355-60; May 1959.

Data from samples of the New Zealand and United States populations lead to the conclusion "that leisure has many different values and is available in many forms to people. It is very largely up to the individual what values he gets from his leisure."—*D. B. Van Dalen.*

78. Etzioni, Amitai. "Authority Structure and Organizational Effectiveness." *Administrative Science Quarterly*, 4: 43-67; June 1959.

"An important factor in the ability of an organization to achieve its goals is its authority structure. If goals and authority structure are incompatible, goals may be modified to the extent that means become parts of the goals themselves. Several organizational assumptions, such as that staff authority is generally subordinated to line authority, are analyzed in different kinds of organizations to show that, in practice, they must be modified according to the major goals of the organization.—*D. B. Van Dalen.*

79. Flanders, Ned A. "Teacher-pupil Contacts and Mental Hygiene." *Journal of Social Issues* 15: 30-39; 1959.

Data from 100 social studies classrooms in Minnesota reveal that teachers use less than 3 percent of their time in praise and encouragement and less than 5 percent reacting to and using ideas that students initiate. The problem of mental hygiene in the classroom appears to be establishing a proper balance between (a) intellectual requirements of classroom functioning vs. social-emotional requirements, and (b) restricted freedom of action for students vs. greater freedom of action. The current data reveals 85 percent of the relationships are intellectual. In classrooms of better teachers 56 percent of the relationships were restrictive of freedom of action. In other classrooms this percentage was 82 percent.—*D. B. Van Dalen.*

80. Fletcher, J. G. "Maximal Work Production in Man." *Journal of Applied Physiology 15*: 764; September 1960.

An analysis was made of the length of time well motivated subjects could step up and down a 22-in. bench at the rate of 30 times per minute. The initial duration of stepping was inversely related to the degree of athletic training or physical activity habits. Subjects who were subsequently trained improved their endurance from two to five-fold. Reduction in post-stepping pulse rate accompanied the training process. Interesting training curves for stepping time are presented. In certain subjects stepping time increased more and more between tests as testing continued with the result that a performance plateau never was reached.—*E. R. Buskirk.*

81. Fox, R. H. "Heat Stress and Athletics." *Ergonomics* 3: 307-13; October 1960.

Certain aspects of man's response to a hot climate are discussed. In order to develop maximum acclimatization it apparently is necessary to work hard in a hot climate as well as being exposed to heat, and it might be best to do this progressively. Illustration is made of the possible effects of the climate in Rome on a marathon runner competing in the 1960 Olympic Games, and the question is raised concerning his ability to eliminate from the body the heat produced during the race.—*David H. Clarke.*

82. Fry, E. "Teaching Machine Dichotomy: Skinner vs Pressey." *Psychological Reports* 6: 11-14; 1960.

In the field of teaching machines, there is a dichotomy of opinion with respect to response mode, step, size, amount of error desirable, learning theory, views on intelligence, and the supplementing of traditional instructional methods.. What we need now are a lot of good experimental studies, both theoretical and applied in nature.—*D. B. Van Dalen.*

83. Frymier, Jack R. "Research for Undergraduates in Teacher Education." *Journal of Teacher Education* 10: 413-16; December 1959.

Does involvement in reading original research reports or doing research as an undergraduate effect a change in attitude toward research? In pre- and post-tests on knowledge of the scientific method, results convinced the author that undergraduates are able and should do and read research.—*D. B. Van Dalen.*

84. Greenacre, P. "Play in Relation to Creative Imagination." *Psychoanalytic Studies of the Child* 14: 61-80; 1959.

Anxiety-provoking problems current in the child's life become the subject of the child's play. The beneficial effect of play in childhood is a reduction of any severe degree of anxiety through illusory mastery sufficient to permit further maturational development to occur and give opportunity to meet similar disturbing experiences in reality later. Other play repetitions may constitute a stage in the development of a potential neurosis. Markedly creative people seem not only to be playful but restless and responsive to the new to an unusual degree. The role of anxiety in connection with

the artistic product varies according to the special nature of the interlocking relationships between the personal self and the artistic self in each creative individual.—*D. B. Van Dalen.*

85. HESS, ROBERT D. "Parents and Teenagers: Differing Perspectives." *Child Study* 37: 21-23; 1959-60.

About 32 adolescents and their parents had personal interviews and answered some written questions. The youngsters first described themselves and their parents and then marked questionnaires as they thought their parents would fill them out. The procedure was reversed with the parents. Both groups agreed in their descriptions of teenagers, describing them in moderately favorable terms. Yet the teenagers felt their parents would underrate them and the parents felt the teenagers would overestimate their own capabilities and maturity. On every item, teenagers rated parents far higher than parents rated themselves. An important answer (in this apparent lack of communication and understanding) may lie in the very different meaning that teenager behavior has for the two generations. Teenagers are more concerned with the immediate problems of maturing. Parents have long-range perspectives and tend to forget the real tensions of adolescence. As the adolescent attempts to redefine himself, to move toward autonomy and establish an adult identity, his tendency to over-estimate adult competence may prove a useful spur. But his feeling that adults devalue his achievements and depreciate his efforts [can] complicate the task of learning and internalizing adult roles.—*D. B. Van Dalen.*

86. HETTINGER, TH., "Das Verhalten der Kraft eine trainierten Muskels während und nach mehrtägger Ruhigstellung" (The relationship between strength in trained muscles before and after prolonged rest). *Internationale Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 357-60; 1961.

The strength of the elbow flexors and extensors dropped 13 percent in four subjects after absolute immobility of the elbow was imposed by means of a cast for one week. The subsequent strength training (one 1-2 second maximal contraction per day for approximately 17 weeks increased the maximum strength at a rate of 9 percent per week. A second one-week absolute rest period then showed a decline in strength of 21 percent, which is significantly more than during the first rest period. Again a training period was started and this showed a weekly increase in strength of 2 percent per week. The latter "restitution" rate was not significanly different from the previous rate of strength increase. The author notes that the above findings may be of importance in the consideration of prescribing bed rest to persons in training.—*J. Royce.*

87. HUNT, JACOB T. "The Adolescent: His Characteristics and Development." *Review of Educational Research* 30: 13-22; 1960.

Research article on physical and mental development, family relationships, social and emotional adjustment, social class and behavior, social attitudes, values, and relationships and vocational interest and aspirations. 98-item bibliography.—*D. B. Dalen.*

88. JACKSON, PHILIP W., and GETZELS, JACOB W. "Psychological Health and Classroom Functioning: A Study of Dissatisfaction With School Among Adolescents." *Journal of Educational Psychology* 50: 295-300; 1959.

This investigation examines the differences in psychological functioning and classroom effectiveness between 2 groups of adolescents—those who are satisfied with their recent school experiences and those who are dissatisfied. The major findings point to: (a) the relevance of psychological health data rather than scholastic achievement data in understanding dissatisfaction with school; (b) the importance of differentiating the attitudes of dissatisfied girls from those of dissatisfied boys, the former being characterized by feelings of personal inadequacy, the latter by feelings critical of school authorities. Rosenzweig's concepts of intropunitiveness and extrapunitiveness are applied to these findings and a relevant theoretical framework is proposed.—*D. B. Van Dalen.*

89. Johnson, R. L., Jr., Spicer, W. S.; Bishop, J. M.; and Forster, R. E. "Pulmonary Capillary Blood Volume, Flow and Diffusing Capacity During Exercise." *Journal of Applied Physiology* 15: 893; September 1960.

Measurements of pulmonary capillary blood flow (Q_C) and apparent CO diffusing capacity (D_L) were made at rest, during exercise (1.5 to 5 mph at 4 to 4.5 percent grade on treadmill) and while performing Valsalva and Mueller maneuvers. D_L was closely related to Q_C ($r = 0.92$) which indicated that the effective surface of the lung bed increased as lung blood flow increased. Ancillary calculations revealed that the pulmonary capillary blood volume also increased as blood flow increased. After starting or stopping, exercise changes in D_L lagged behind changes in Q_C but steady state values for both were usually reached within one minute. It was estimated that exercise which tripled pulmonary capillary blood flow reduced the stay of red cells in the pulmonary capillaries from 0.8 seconds at rest to 0.5 seconds.—*E. R. Buskirk.*

90. Jones, Frank Pierce, and Gilley, Philip F. M., Jr. "Head-balance and Sitting Posture: An X-ray Analysis." *Journal of Psychology* 49: 289-93; April 1960.

An empirical method for changing the distribution of postural tonus by changing the reflex balance of the head. The change is characterized by a kinesthetic effect of lightness which carries over into subsequent movements. X-ray photographs of 20 normal adults were used to study the relation between the head and neck in 2 erect sitting postures, "habitual" and an "experimental." In the latter the balance of the S's head was altered by the E while the posture was being assumed. The postures were found to differ significantly in 2 linear and 2 angular measures taken from the X-ray photographs. A hypothesis is advanced to explain the kinesthetic effect of lightness as the result of a change in the reflex balance between the tonus of neck muscles and the gravitational forces acting on the head.—*D. B. Van Dalen.*

91. Kerlinger, Fred N., and Kaya, Esin. "The Predictive Validity of Scales Constructed to Measure Attitudes Toward Education." *Educational Psychological Measurement* 19: 305-17; 1959.

A methodology was used to determine item factor validity on 2 scales designed to measure attitudes toward education. The 2 factors were labeled progressivism and traditionalism, and they were shown to be independent. Both scales differentiated among undergraduate education students, graduate education students, and people outside of the university. The study makes a methodological contribution in demonstrating the convergence of the concepts of logical and empirical validity. The rather low reliabilities of the 2 scales are attributed to the paucity of items. Reliability r's ranged from .54 to .85 with medians of .76 and .72 for the 2 scales. The implications of the rather sharp differences in attitudes of education students and outside people are discussed.—*D. B. Van Dalen.*

92. Klein, Karl K. "The Deep Squat Exercise as Utilized in Weight Training for Athletics and its Effect on the Ligaments of the Knee." *Journal of the Association for Physical and Mental Rehabilitation* 15: 6-11; January-February 1961.

The anatomy and kinesiology of the knee joint is presented, with particular emphasis upon the ligamentous and cartilaginous function. A series of measurements were made on 64 dissected knees to determine the tension of the ligaments in the standing and deep squatting positions, with the observation that the medial and lateral ligaments were exposed to abnormal stretch in the later position. A study of 128 competitive weight lifters and 386 control subjects demonstrated the instability of the knee joint in those that practiced the deep squat exercise. Implications for conditioning and for competitive lifting are presented.—*David H. Clarke.*

93. Köning, K., Reindell, H., Keul, J., and Roskamm, H. "Untersuchungen über das Verhalten von Atmung und Kreislauf im Belastungsversuch bei Kindern und Jugendlichen im Alter von 10-19 Jahren," "Investigation of the relationship of

respiratory and circulatory factors to work load in children and youths of 10 through 19 years of age"). *Internationale Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 393-434; 1961.

A total of 271 male children, divided into five groups as to ages 10-11, 12-13, etc., performed a bicycle ergometer task in a lying position. The work was stepped up from 50-watt to 250-watt in systematic increments. During rest and work the O_2 intake, CO_2 production, ventilation, pulse rate, and blood pressures were obtained. Tables and graphs are provided to show the changes in the above variables and their derivatives (R. Q., pulse pressure, ventilation/O_2 intake, O_2 intake/pulse rate) with age. Each variable is thoroughly discussed in the light of previous research findings.—*J. Royce.*

94. Leshner, Saul S. "The Effects of Aspiration and Achievement on Muscular Tensions." *Journal of Experimental Psychology* 61: 133-37; February 1961.

This study attempts to determine whether aspiration stated in realistic (expectant) terms exerts an influence upon muscle tension levels that is different from irrealistically (hopefully) expressed aspirations.

It was found that the rate of tension increase is significantly greater in subjects who stated expectations and failed than in subjects who stated irrealistic aspirations and failed.

Tension levels produced during work decrease in subjects who succeed and increase in subjects who fail, irrespective of the hopefulness or expectancy of aspiration.—*Vera Skubic.*

95. Leverett, E. "Basic Requirements in College Curricula." *School and Society* 89: 186-7; April 8, 1961.

A study of recent bulletins of 140 colleges in 43 states indicates the following with respect to health and physical education: "There seems to be a new trend in requirements in the area of health and physical education. A few decades ago, practically all schools required at least one course in health and hygiene and at least four semesters of physical education; now 25 schools (17.8 percent) do not require any courses in either physical education or health; two schools require only one hour of physical education; 20 (14 percent) require two hours; five require three hours; 58 (41 percent) require four hours; nearly 30 percent require no activity credit; 25 schools (17.8 percent) require from 0-7 hours in health and hygiene (a few schools who require a course in this area give no credit for it). One school permits band to count for physical education; another school requires two semesters of physical education but gives no credit."—*T. Erwin Blesh.*

96. Malhatra, M. S., Ramaswamy, S. S.; and Ray, S. N. "Effect of environmental temperature on work and resting metabolism." *Journal of Applied Physiology* 15: 769; 1960.

Measurements of energy expenditure for various activities were made on eleven young adult male subjects (Indian) at several intervals throughout a year. The mean maximum and minimum dry bulb temperatures ranged from 22.8 to 39.0°C and from 8.4 to 27.2°C respectively. The winter values averaged about 3 percent higher than those for summer, but correction for the weight gain in winter indicated that this difference was not significant. The conclusion that climate had little influence on working metabolism is in keeping with the results of comparable investigations performed in recent years which have covered even wider climatic extremes.—*E. R. Buskirk.*

97. Mandler, G. and Kuhlman, C. K. "Proactive and Retroactive Effects of Overlearning." *Journal of Experimental Psychology* 61: 76-81; January 1961.

The study was concerned with the effect of overlearning of a complex motor response on the learning and retention of another, similar response.

Five groups of ten subjects each were required to perform four tasks. On Task 1 they learned a motor pattern consisting of a sequence of 8 switches on a 64 unit switch-

board. On Task 2 they learned a different pattern on the same board. On Tasks 3 and 4 they relearned the first and second patterns, respectively. The five groups differed in the amount of training they received on each task; they either learned the pattern to mastery (five successive errorless trials) or were given 50 trials beyond mastery.

The results showed that following the acquisition of one pattern, learning of a second pattern was superior to learning of the first. Overlearned patterns were more easily recovered than patterns learned to mastery only. Overlearning of an intervening pattern increased retroactive interference on Task 3; it facilitated performance on Task 4.—*Vera Skubic.*

98. Mellerowicz, H.; Meller, W.; and Müller J. "Vergleichende Untersuchungen über Leistungssteigerung durch Intervalltraining und Dauertraining bei gleicher Trainingsarbeit," (Comparative study of the effect of intermittent versus continuous training programs with equal total work). *Internationale Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 376-85; 1961.

Out of a total of 24 boarding house students (male, age 11-19) two groups were formed that were approximately equal in average weight, height and performance on a hand and arm (crank) ergometer. The first group exercised on a nonintermittent program, while the second group trained according to an intermittent exercise program. The second group was subdivided into two subgroups which differed in the division of work and rest time, the total amount of work, however, being equal. Four weeks of training (3 times a week) produced an average 23 percent increase in performance, but no difference was found between the two methods of training.—*J. Royce.*

99. Milic-Emili, G.; Petit, J. M.; and Deroanne, R. "The Effects of Respiratory Rate on the Mechanical Work of Breathing during Exercise." *Internationale Zeitschrift für angewandte Physiologie einschliesslich Arbeitsphysiologie* 18: 330-40; 1960.

Records were obtained of endoesophageal pressure and tidal volume on three normal subjects exercising on a bicycle ergometer. Respiratory rate was self-determined (i.e., "spontaneous") or regulated by metronome ranging from 20 to 60 cycles per minute. The lower the respiration rate the more the rise in ventilation rate resulted in increased mechanical work of breathing. When allowed to increase ventilation without any control of respiratory rate, the subjects spontaneously chose respiratory rates and levels in the range where pulmonary ventilation involved minimal effort.—*J. Royce.*

100. Moore, Terrence W. "Studying the Growth of Personality." *Vita Humana* 2: 67-87; 1959.

"Psychological data collected during the first 7 years of [a longitudinal study of child development] are surveyed and their uses considered. Ten key questions are propounded, and the programs of analysis resulting from their application to behavioral data of various types are considered . . . These concern: (1) incidence and distribution of behavior items age by age; (2) prediction from one age to another; (3) relation between behavior and constitutional factors; (4) effects on behavior of situation and observer; (6) effects of crucial experiences; (7) effects of parental management; (8) the influence of social factors; (9) comparison of samples in different countries; and (10) the study of individuals."—*D. B. Van Dalen.*

101. Porter, Eugene, and Wehr, R. Eugene. "Oral Poliomyelitis Vaccine Program in Cincinnati." *Public Health Reports* 76: 369-74; May 1961.

The Sabin oral vaccine was used in a 1960 special vaccination program in the concentrated populated area of Cincinnati. This program was designed to reach residents of Cincinnati with all appropriate devices of persuasion and promotion and with the help of a large volunteer educational committee.

A total of 181,784 persons received at least the type one vaccine. Of these, 178,761 were children of preschool or school age who also received type two or three doses.

No cause or effect relationship between the vaccine program and incidence of poliomyelitis in Cincinnati can be assumed, but no clinically diagnosed cases of the disease occurred in Cincinnati in 1960 contrasted to the 24 cases of paralytic poliomyelitis reported in greater Cincinnati in 1959.—*Ethel Tobin Bell.*

102. RACHMAN, S. "Effect of Stimulant Drug on Extent of Motor Responses." *Perceptual and Motor Skills* 12: 186; 1961.

Two doses of dexamphetamine (5 and 10 mg.) and a placebo were given to 6 normal males (Ss) on separate days. Following an incomplete Latin Square design each S was tested on 3 consecutive days, and 2 hours after administration of the drugs and/or placebo. S moved a lever, mounted on a platform, to the right or left in response to different signals. There was no difference in extent of response between placebo and 10 mg. dose, but a significant difference was found between the large dose (10 mg.) and the placebo, the response with the drug being less. This indicated to the author that greater accuracy and economy of motion are the result of the added cortical stimulation produced by the drug.—*C. Etta Walters.*

103. RASCH, PHILIP J. "Progressive Resistance Exercise: Isotonic and Isometric: A Review." *Journal of the Association for Physical and Mental Rehabilitation* 15: 46-50; March-April 1961.

The literature is reviewed concerning the value of isotonic and isometric exercise as a method of increasing muscular strength, and certain physiological factors are discussed.—*David H. Clarke.*

104. RASCH, PHILIP J., and HUNT, M. BRIGGS. "Some Personality Attributes of Champion Amateur Wrestlers." *Journal of the Association for Physical and Mental Rehabilitation* 14: 163-64; November-December 1960.

Fourteen candidates for the 1960 Olympic wrestling team were given the Berdie test of masculinity-femininity to determine if their scores would resemble those of known male homosexuals or those of college freshmen in general. It was concluded that the wrestlers did not differ appreciably from the male freshmen. It further became evident that they considered themselves straightforward, mature, modest and masculine.—*David H. Clarke.*

105. RICE, CHARLES; BERGER, DAVID G.; SEWALL, LEE G.; and LEMKAN, PAUL V. "Measuring Social Restoration Performance of Public Psychiatric Hospitals." *Public Health Reports* 76: 437-46; May 1961.

The Medical Audit Plan for Psychiatric Hospitals, a research program to develop a method for appraising the effectiveness of public psychiatric hospitals may be divided into three time phases: collection, observation and followup. Collection of data for level one includes satisfying the resident cohorts by length of hospital stay and recording basic demographic information of patients before study is launched. Level two measures the average number of days spent in the community by a released member. Level three, the most direct measure of hospital success, is a study of adjustment. Patients serve as their own controls and the role of the hospital in contributing changes in adjustment of patient cohorts is evaluated.

Application of this methodology is being planned for a series of state hospitals with the hope for improving end results in hospital effort.—*Ethel Tobin Bell.*

106. SIEBERT, WERNER W. "Investigation of Hypertrophy of the Skeletal Muscle." *Journal of the Association for Physical and Mental Rehabilitation* 14: 153-57; November-December 1960.

This translation of an earlier German review (1928) is primarily concerned with the development of muscle hypertrophy. The concept of work and effort (work/time) is examined, and the results of laboratory experimentation with rats are reported. The effect of isometric and isotonic muscle action is investigated as well as the issue of hypertrophy and hyperplasia in the enlargement of skeletal muscle.—*David H. Clarke.*

107. SIMON, J. RICHARD. "Changes With Age in the Speed of Performance on a Dial Setting Task." *Ergonomics* 3: 169-74; April 1960.

Two age groups, approximately 22 and 70 years, were compared on a task in which two dials had to be set alternately. The precision required to adjust the dials was systematically varied. A marked increase with age was noted in the time taken to adjust the dials, but a much smaller increase was observed in the time spent moving the hand from one dial to the other. The time taken to travel between the dials depended on the precision of both the preceding and the following manipulations.—*David H. Clarke.*

108. SMITH, KARL U. "The Geometry of Human Motion and Its Neural Formulations. 1. Perceptual and Motor Adaptation to Displaced Vision." *American Journal of Physical Medicine* 40: 71-87; 1961.

This is the first of two articles on motion and vision. It deals with the experiments on adaptation to displaced vision and its effect on motor performance. Several significant findings, which are relevant to an effective theory of the relationship between perception and coordinated movements, are listed. The neurogeometric theory of perception and motion is touched upon.—*C. Etta Walters.*

109. SMITH, KARL U.; MCDERMID, CHARLES D.; and SHIDERMAN, FREDERICK E. "Analysis of the Temporal Components of Motion in Human Gait." *American Journal of Physical Medicine* 39: 142-51; August 1960.

Paper describes the application of electronic methods (the electro-basometer) of motion analysis to measurement of gait in man. The authors believe this instrument may be applicable to anthropological as well as medical and physiological uses. They present a psychophysiological as contrasted to a mechanical theory of gait.—*C. Etta Walters.*

110. SNELLEN, J. W. "External Work in Level and Grade Walking on a Motor Driven Treadmill." *Journal of Applied Physiology* 15: 759; September 1960.

Through use of a specially designed chamber facility in which air and wall temperatures could be matched to mean surface temperature of the body, an experimental check was made on the validity of two commonly held assumptions: (1) the external work in grade walking equals the product of body weight and the height climbed, (2) energy is not converted into heat outside the body in level walking. In grade walking, at thermal equilibrium there was a difference between heat production and heat loss by evaporation (radiation and convection were assumed to be negligible because of the environmental control). This difference was approximately equal to the product of the body weight and height climbed which tends to verify (1). In level walking heat loss by evaporation tended to equal heat production which indicates that (2) is also a reasonable assumption.—*E. R. Buskirk.*

111. SPAIN, DAVID, and BRADESS, VICTORIA. "Occupational Physical Activity and the Degree of Athersclerosis in 'Normal' Men." *Circulation* 22: 239-42; August 1960.

The degree of coronary athersclerosis was estimated in 207 autopsies of hearts of normal males, whose ages at death ranged from 30-60. Deaths were due to sudden accident, suicide, or homicide. One hundred were from sedentary occupations (clerks, accountants) and 107 were from occupations requiring considerable physical activity (construction workers, letter carriers). There were no significant differences in the incidence of athesclerosis between the two groups.—*Clifford E. Keeney.*

112. STEINBERG, SHELDON S., and FITZPATRICK, EUGENE D. "The Paducah Health Education Survey, 1958." *American Journal of Public Health* 51: 732-45; May 1961.

In a study undertaken in Paducah, Kentucky to see whether a mass information campaign would significantly affect knowledge and attitudes about a health problem, it was found that even though a media campaign was effective, the personal contact

between interviewer and the interviewee reinforced the psychological readiness to absorb information.

The study was conducted in four major steps: (1) teaching sample population to determine level of knowledge about a specific health problem (in this case arthritis and rheumatism were chosen); (2) conducting a three-day saturation campaign of information over mass media; (3) retesting the original sample and testing a control group to determine where there was a significant increase in knowledge level; (4) post-testing to determine retention of knowledge after a six-month period. Although all of the questions originally posed in the study were not satisfactorily answered, it was found that lay public can be "sensitized" and motivated" to seek information about a disease by the personal contact of the questionnaire-interview method and suggests more thorough investigation to determine campaigns that would be most effective for various educational levels.—*Ethel Tobin Bell.*

113. Strange, F. G. St. Clair. "Some Aspects of Muscle Mechanics." *Proceedings of the Royal Society of Medicine* 52: 897-99; November 1959.

The gluteus medius is normally described as an abductor of the hip, i.e., an abductor of the femur on the pelvis. In everyday life this is a rare activity. The real function of the muscle is the abduction of the mobile pelvis on the fixed femur and the prevention of adduction of the pelvis on the weight-bearing hip under the superincumbent body weight. After leg injury the patient tends to reduce the movement of his body weight about the hip by moving his center of gravity laterally. If he brings it vertically over the hip, there is no longer a demand on the gluteus medius and the body weight falls vertically over the top of the head of the femur. The gluteus medius limp results. No amount of leg abduction exercises alone will retrain weak glutei. The essential activities are reeducation in trunk carriage, pelvic posture, and walking.

In walking the tibialis anterior prevents the foot from being forcibly plantar-flexed—the obvious feature of the drop-foot gait. It must catch the body weight at each step and transfer the downward acting kinetic energy into a forward direction. This means it must act while lengthening instead of while shortening. In the restoration of function to a weakened tibialis anterior, attempts to make the foot dorisflex against resistance should be abandoned as an activity unknown in normal life. We should concentrate on pressing a resistance away with the undersurface of the heel.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

114. Tenbergen, N. "The Evolution of Behavior of Gulls." *Scientific American* 6: 118-30; December 1960.

This leading ethologist presents additional evidence of the inheritance and development of behavior patterns.—*R. Glassow.*

115. Thomas, Caroline B., and Garn, Stanley M. "Degree of Obesity and Serum Cholesterol Level." *Science* 131: 42; January 1960.

No significant correlation was found between serum cholesterol level and weight, weight corrected for frame size (body weight/chest breadth), or thickness of the fat shadow in 159 white, male medical students (mean age 22 years).—*Clifford E. Keeney.*

116. Thurman, Robert S. "Men Teachers in Public Elementary Schools." *Journal of Educational Research* 54: 54-57; October 1960.

This study, confined to men teaching in grades one through six, was an examination of the role and status of men teachers in public elementary schools in the United States and of the problems peculiar to these men. It included: (a) a study of personal and professional data; (b) an examination of the opinions of superintendents, men elementary school teachers, P.T.A. presidents, and other specially selected educators concerning the role and status of men teachers in elementary schools; (c) a determination of the unique contributions, if any, that men were thought to make as elementary teachers; and (d) a determination of some of the problems that might discourage men from entering or remaining in elementary education.

An opinionnaire, devised to determine views of various groups regarding the role and status of men teachers in elementary schools, and a questionnaire, sent only to men elementary school teachers in order to gather personal and professional information, were the instruments used for obtaining data. Many findings were noted from the study, but of great concern is the fact that less than one-fifth of the men planned to remain classroom teachers. Specific recommendations should be made to provide adequate salaries, to reduce the concept that elementary school teaching is a feminine occupation, and to increase the professional status of all teachers.—*T. Erwin Blesh.*

117. Toch, Hans H. "Can Eye Dominance Be Trained." *Perceptual and Motor Skills* 11: 31-34; August 1960.

Eye dominance was pretested in a control and experimental group. Experimental group was trained with consecutive stereoscopic presentation of slides, with dominant field always for left eye. Control group was presented with stereograms which produced composite images. Pretest showed tendency toward right-eye dominance. Although this tendency was not present in the post-tests, there was no significant difference between the two groups.—*C. Etta Walters.*

118. Vernon, Jack A., and others. "Effect of Sensory Deprivation on Some Perceptual and Motor Skills." *Perceptual and Motor Skills* 9: 91-17; June 1959.

The effect of Sensory Deprivation (S.D.) lasting 24, 48, or 72 hr. was measured for several perceptual and motor skills. It was found that color perception was adversely affected especially when confinement extended to 48 and 72 hr. There was no significant effect of S.D. upon depth perception, probably because of the large individual variations in performance. Rotary pursuit ability was significantly adversely affected by S.D. only when confinement lasted 48 hr. A similar finding resulted for the time required to perform a standard mirror tracing task. However, the errors made on the mirror tracing task were fewer after 48 hr. of confinement and significantly increased after 24 and 72 hr. of confinement. Gross motor behavior as measured by a rail walking task was adversely affected by S.D., especially after 72 hr. of confinement. All S.D. effects were somewhat temporary in nature since tests given 24 hr. after release from confinement revealed a tendency toward elimination of effects produced by S.D. Although results are based upon small Ns and single brief measures at each test period, the effects of S.D. upon performance are fairly consistent.—*D. B. Van Dalen.*

119. Wall, James. "Tennis Elbow." *Industrial Medicine and Surgery* 29: 173-75; April 1960.

Over the last four years 95 cases of tennis elbow were experienced at one General Electric plant. The exact pathology of this condition is obscure, but it appears to be a traumatic lesion involving the periosteum over the lateral humeral epicondyle and the inserting fibers of the conjoined tendon, a fascio-periostitis with local edema, and perhaps adhesion formation. About 1 cc of 2 percent novocaine is injected, followed by 1 cc of hydrocortone acetate. The elbow usually becomes acutely painful as a result of these injections and the patient is supplied with empirin compounded with codeine. A total of 88.6 percent of the patients were completely or significantly relieved by this treatment, although some required additional injections. There have been no untoward reactions or complications.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

120. Wang, Yang; Marshall, Robert J.; and Shepherd, John T. "The Effect of Changes in Posture and Graded Exercise on Stroke Volume in Man." *Journal of Clinical Investigation* 39: 1051-61; July 1960.

The authors state that in the studies reviewed by Rushmer and Smith, where information was presented to lend support to the new concept that an increase in stroke volume is not an essential feature of the ventricular response in normal human subjects, the subjects had exercised in various positions, and this could have accounted for much of the discrepancy.

In this article, cardiac output, measured by the indicator-dilution method, heart rate and stroke volume were measured in four healthy, untrained men at rest in the supine position, at rest standing, and during exercise in the upright position. The exercise varied in intensity from gentle movements of the calf muscle and marking time to walking at 4.5 mph up a treadmill inclined at 12 deg. from the horizontal. Cardiac outputs of 15 and 25 L per minute and oxygen consumptions of 2.0 and 2.8 L per minute were associated with the highest work load. The stroke index averaged 54 ml at rest in the supine position, and 32 ml at rest standing, a fall of 41 percent. With moderate exercise in the upright position the stroke index was similar to that obtained when the subject was at rest in the supine position. The stroke volume increased to 59 ml with severest exercise.

In making comparisons of exercise and resting stroke volumes, the positions of the subjects must be the same in both instances. The authors conclude that when this is done, increases in stroke volume are comparable with those in heart rate.—*R. H. Rochelle.*

121. Washburn, Sherwood L. "Tools and Human Evolution." *Scientific American* 3: 63-75; September 1960.

Excavations in Tanganyika in 1959 present clear evidence that a preman species used tools to kill small animals for food. The continued use of tools for hunting stimulated biped locomotion and the resulting demands on hands and feet led to structural changes in pelvis and skull. Excellent illustrations of skeletal changes.—*R. Glassow.*

122. Welford, A. T. "The Measurement of Sensory-Motor Performance: Survey and Reappraisal of Twelve Years' Progress." *Ergonomics* 3: 189-230; July 1960.

The historical development during the past twelve years of the measurement of sensory-motor performance is presented, with particular emphasis on the capacity of the human information channel. In this respect, five areas are considered: (1) the single-channel hypothesis; (2) stages of central activity; (3) choice reaction times; (4) control of movement; and (5) perceptual identification and discrimination. In the central mechanisms, signals must be dealt with one at a time, so that others must queue up until the central mechanisms are free. These mechanisms do not act as a single whole, but as a chain with at least three links. Information theory models relating to the speed and accuracy of movement are discussed as well as several formulas which attempt to relate time taken to discriminate quantities of different magnitudes and the fineness of the difference between them.—*David H. Clarke.*

123. Werdein, Edward J., and Kyle, Laurence H. "Estimation of the Constancy of Density in the Fat-Free Body." *Journal of Clinical Investigation* 39: 626-29; April 1960.

Estimations of body fat by densiometer measurements are predicated on the assumption that the fat-free body mass of normal persons possesses a constant density. However, Keys and Brozek have pointed out that the density of the fat-free body is unknown, and could deviate with overfeeding or starvation. When current techniques of estimating total body fat were applied to subjects with a wide range of body build and varied physical fitness, obesity, and age, a considerable variance of fat-free body density was found. While useful for the estimation of change in body fat, densiometric and volume distribution methods possess inherent weaknesses.—*P. J. Rasch, Journal of the Association for Physical and Mental Rehabilitation.*

124. Wickstrom, Ralph L. "The Effect of Low-Resistance, High-Repetition Progressive Resistance Exercise Upon Selected Measures of Strength and Flexibility." *Journal of the Association for Physical and Mental Rehabilitation* 14: 161-62; November-December 1960.

Low-resistance, high repetition (15-20) weight training was participated in by 64 college men twice a week for 12 weeks. Significant increases were obtained in trunk

flexibility and strength measures of arm flexion, trunk extension and trunk flexion, but no change occurred in arm flexibility. The exercise program apparently had less effect upon those who were less flexible at the beginning than those who were more flexible.—*David H. Clarke.*

125. WILKIE, D. R. "Man as a Source of Mechanical Power." *Ergonomics* 3: 1-8 January 1960.

Observations were made on the various types of exercise presented in the literature concerning champion athletes and normal healthy nonathletes. The usable external power output of the body is limited (a) in single movements of duration less than one second (less than six h.p.), by the intrinsic power production of muscle; (b) in brief bouts of exercise of 0.1 to 5 min. (2—0.5 h.p.), by the availability in the muscle of stores of chemical substances that can yield energy by hydrolysis; (c) in steady state work of 5—150 min. or more (0.5—0.4 h.p.), by the ability of the body to absorb and transport oxygen; and (d) in long-term work, lasting all day (to 0.2 h.p.), by wear and tear of muscles, the need to eat, etc. It is apparent that ordinary healthy individuals can produce less than 70 to 80 percent as much power as champion athletes.—*David H. Clarke.*

126. WILKINSON, R. T. "Rest Pauses in a Task Affected by Lack of Sleep." *Ergonomics* 2: 373-80; August 1959.

Twelve male volunteers were given a 25-minue five-choice test, a serial reaction task, and subjected to a system of sleep deprivation. Results confirmed previous research by demonstrating that 30 hours' loss of sleep seriously impaired performance. The occurrence of gaps, or abnormally long response delays, was greatly increased, particularly when the test is given continuously. However, when 30-sec. rest pauses were allowed every five minutes, this effect of lack of sleep was found to remain unaltered, an equal though small and insignificant improvement in performance occurring under both normal and sleep-deprived conditions.—*David H. Clarke.*

127. WILLIAMS, HARVEY E.; DRURY, BLANCHE J.; and BIERMAN, WILLIAM. "The Influence of Cyclo Massage on Physical Activity." *Journal of the Association for Physical and Mental Rehabilitation* 15: 41-5; March-April 1961.

Male and female college students were given the Burpee, two trunk flexibility tests, and a grip strength test. This was followed by the administration of cyclo massage to the paravertebral areas of the back and posterior portion of the lower extremities. Flexibility was significantly greater in the experimental than the control group, but no change occurred in the Burpee test. Variance analysis, however, revealed that the differences in massage techniques did not contribute to the difference in performance scores. Further, massage applied to the hand and forearm did not affect the grip strength. Subjective evaluation reflected a greater general relaxation by the subjects during the performance of the tests.—*David H. Clarke.*

128. WOLDRING, S. "The Mechanics of Breathing, General Principles and Techniques of Measurement." *Proceedings of the Tuberculosis Research Council* (Netherlands) 46: 5-27; 1960.

The basic principles of the mechanics of lung ventilation are presented. Lung volume, flow rate, and intrathoracic pressure are shown to be interrelated and to depend on the elastic properties of the lungs and resistance of the air passage to the flow. The factors involved are discussed and expressed in mathematical equations. The instrument for the simultaneous recording of volume, pressure, and flow is described.—*J. Royce.*

Guide to Authors

IN LINE WITH the over-all goal of making Association publications yield the greatest value to the individual and the profession, the following is a guide for the preparation of manuscripts for the *Research Quarterly*, recognizing general techniques employed by educational research publications.

Manuscripts should be sent to the Managing Editor (AAHPER, 1201 Sixteenth Street, N.W., Washington 6, D. C.), who will see that each one is read by at least three members of the *Research Quarterly* Board of Associate Editors. On the basis of the three reviews, the Managing Editor will advise the author as to the suitability of the paper or the desirability for revision. Papers are judged on their content of new research results in the field of physical education, health education, and recreation, presented with the greatest brevity compatible with scientific accuracy and clarity. Manuscripts are considered for publication as articles or as notes or comments. For more detailed information, see "Criteria for Evaluation of Articles Submitted for Publication in the *Research Quarterly*," in the October 1959 *Research Quarterly*, p. 381.

Since three members of the Board of Associate Editors review an article, it is requested that three clear copies of the manuscript be submitted in order to facilitate reviewing. A fourth copy of the article should be retained by the author.

Typewritten manuscripts should be double spaced on white paper of ordinary weight and standard size (8½ x 11 in.). A brief abstract of the article, 100 words or less, should be typed double space on a separate sheet (see abstracts at head of *Quarterly* articles for style). The abstract should be a summary of the purpose, procedure, and findings of the study.

The sheets of manuscript should be kept flat. The pages of the typewritten copy should be numbered consecutively in the upper right-hand corner. Paragraphs should be numbered consecutively throughout the manuscript.

Headings

The headings should be typed so as to show relative values. Usually two gradations are sufficient: (a) major subdivisions of the article, aligned on the left and underscored in manuscript with wavy line; (b) subheads, underscored in manuscript and run in at the beginning of the paragraph or section. If it is necessary to use additional subdivisions, use subheads in capital letters, aligned on the left. If needed, this division should be inserted between a and b above (as demonstrated in this guide).

Documentation

FOOTNOTES

Footnotes are not to be used for references or literature citations. Rather they are used for the purpose of acknowledgment, special explanation, supplementary information, etc., as in the examples below.

Footnotes should be numbered from 1 up for each article, a corresponding numeral (placed above the line, like this [4]) appearing in the text. Asterisks should not be used. Type footnotes double space.

Examples of Footnotes. Following are examples of the kinds of footnotes which are acceptable:

[1]This study was made under the direction of Arthur T. Slater-Hammel in the Research Laboratories, School of Health, Physical Education, and Recreation, Indiana University, Bloomington, Indiana.

[2]All measurements of the hand were recorded in centimeters, and height was recorded in inches. The hand measurements were taken by Everett, and reliability coefficients of above .90 were found for each measurement used in the study.

[3]Appreciation is expressed to members of the Boston University varsity football squad and to Buff Donelli and his coaching staff for their co-operation in this study.

Tables often require footnotes. These should be identified by letters of the alphabet rather than asterisks.

CITATIONS OF LITERATURE

Citations of literature should be arranged alphabetically by author's last name. They should be typed at the end of the article, under the heading "References." *Do not treat them as footnotes.* Type references double space.

Numbering. The literature citations, arranged alphabetically, should be numbered consecutively, their location in the text being indicated by corresponding numbers enclosed in parentheses, for example (1), (2, 3). The reference number in the text should immediately follow the title or author's name.

Uniform Style. A uniform style should be maintained in writing citations. Enclose titles of chapters and articles in quotation marks. Italicize (underscore in manuscript) names of books, periodicals, bulletins, etc. (See examples below.)

Uniform sequence of data should be observed, as follows: *For a book*—Author's name (last name first); title of article or chapter; name of book; place of publication; publisher; year date. *For a periodical*—Authors' name (last name first); title of article or chapter; name of periodical; volume number; inclusive page numbers; month and year date.

Alphabetization. When placing references in alphabetical order, last names beginning with "Mc" are treated like "Mac"; references by the same author are listed in order according to title; references by the same author with different co-authors are listed in order according to co-author.

Examples of References. Following are some samples incorporating the above principles. Note that author's first name should be given if possible and that all authors' names are reversed.

1. American Association for Health, Physical Education, and Recreation. *Health in Schools.* Washington, D. C.: the Association, a department of the National Education Association, 1951. 328 p.
2. Deaver, Gordon G. "Exercise and Heart Disease." *Research Quarterly* 26: 24-34; October 1955.
3. Deaver, Gordon G. "Weight and Heart Disease." *Physiological Hygiene.* (Edited by N. S. Long.) New York: McGraw-Hill Book Co., 1959. 469 p.
4. Ogden, Jean; White, Jess; and Smith, Wynn. *Small Communities in Action.* New York: Harper & Brothers, 1956. 250 p.
5. Potter, John Nicholas. *Physical Fitness of Junior High School Boys.* Unpublished Master's thesis. Berkeley: University of California, 1958.
6. Potter, John Nicholas, and others. "Comparison of Practice Periods in Learning." *Journal of Educational Psychology* 17: 150-62: July 1957.

Tabular Matter

Each table should have a descriptive heading and should be specifically referred to in the text by number, e.g., "Table 10," never as "the above table" or "the following table." Number tables from 1 up for the entire manuscript, using Arabic numerals. Do not duplicate data by giving them in *both* tables and graphs.

Tables should be typewritten double space, like the rest of the material in the manuscript. Each table should be typed on a separate sheet. If a table continues on a second sheet, it is not necessary to repeat the boxheads.

The word "table" should be written in capital letters, as "TABLE 1.—"; the table title should also be written in capitals, centered over the table. Tables should be ruled as desired, except that no rules will appear at the extreme right and left edges of the table. No double rules are to be used, unless necessary for clarity.

Illustrations

Illustrative material is of two types: pen and ink drawings, which are reproduced by the line engraving process; and photographs, wash drawings, stipple drawings (in short, anything containing shading), which are reproduced by the halftone process. All illustrative material (considered as figures) should be numbered consecutively from I up for the entire manuscript. Use Roman numerals to number figures.

Copy for Line Engravings. All drawings should be made with India ink, preferably on white bristol board plate, 1 ply or 2 ply. Avoid graph paper for the reproduction copy, as the printing interferes with proper inking and the paper permits no corrections. Sometimes it is desirable to ink in the principal guide lines so that the curves can be more easily read. Good examples of graphs can be seen in the *Research Quarterly* for May 1959, on p. 194-95.

Lettering should be plain and large enough to reproduce well when the drawing is reduced. Keep in mind the dimensions of the printed page (4⅛

x 7 in.). Most figures can be advantageously drawn for a linear reduction of one-half or one-third. Be sure to draw the lines heavy enough so that they will not be overly thin after reduction. Explanatory lettering should be included within the chart. Typewritten lettering does not reproduce well; it is much better to use a Leroy or similar lettering device.

Care should be taken not to waste space, as this means greater reduction and a less satisfactory illustration. Often it is possible to combine several curves in one figure and enable the reader to make comparisons.

Copy for Halftones. Photographs should be clear black-and-white prints on glossy paper. Care should be taken to see that they cannot be bent or folded in handling and mailing. *Paper clips should not be used,* for all imperfections are reproduced.

The legends for the illustrations should be clearly identified and typed on a separate sheet placed at the end of the manuscript. Care should be taken to indicate clearly in the text the location of all illustrations and tables.

Special Points of Style

Well-known statistical formulas should be omitted. Extensive tabular material, raw data, and appendixes should not be printed; the author can mention in a footnote that he will supply such material in mimeographed form on request.

Use of Numbers. Use Arabic figures for all definite weights, measurements, percentages, and degrees of temperature, e.g., 2 kmg., 1 in., 20.5 cc., 2 percent, 300° C. For numerals used in a general sense, spell out numbers through ten and use Arabic figures for 11 and over (seven times, five years old, 11 students.)

Abbreviations and Symbols. Standard abbreviations should be used whenever the weights and measurements are used with figures. All obscure and ambiguous abbreviations should be avoided. Percent should be one word. Use percent sign (%) in tables or when it appears in parentheses in text. Use standard symbols. Do not underline or put symbols inside quotation marks.

Proofreading

The author will receive his original manuscript and any engraver's proofs with the galley proofs of his article for correction. Corrected proofs and original manuscripts are to be returned within 48 hours after receipt by first-class mail to the Managing Editor, *Research Quarterly*, AAHPER, 1201 Sixteenth Street, N. W., Washington 6, D. C.

A reprint order blank will be enclosed with proofs. It should be returned whether or not reprints are wanted.

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